BOOK OF WONDERS AND CURIOUS THINGS

THE · BOOK · HOUSE ·

A BOOK is just a House of Thought,
Where many Things and People live.
Beyond its doors Great Things are taught,
And all its Dwellers give and give.
So walk right through the open door
With kindly Heart and brain awake.
You'll find in there a Wonder Store
Of Good Things, all for you to take.

The Dwellers in *your* Book House know
All sorts of tales to tell to you,
And each will try his best to show
The way those tales of Wonder grew.
For this our Book House Friends expect
A trifling payment in return;
Just thoughtful Kindness and Respect,—
That's all they *ask* for all we *learn*.

John-martin

This BOOK belongs to

THE BOOK TREE

A BOOK TREE is a Knowledge Tree,
As almost anyone can see.
Long, long ago its seed was sown;
For *years* and *years* the Tree has grown.
Ten thousand thousand Hearts & Heads
Have cared for it, so now it spreads
Its Roots and Branches far and wide,
And casts its shade on every side.

This Tree bears Fruit of different kinds
For many Hearts and many Minds.
So all you Children have to do
Is just to take what's *best* for you.
But no one ever soils or breaks
The Golden Fruit he *needs* and takes,
And no one ever bends or tears
The Books this Tree of Knowledge bears.

"John-martin"

Copyright 1910 by Morgan Shepard

IN 1950. THE CLASS IN HISTORY.

TEACHER: "NOW, JOHNNY, TAKE THE POINTER AND SHOW THE CLASS JUST THE SPOT WHERE COLUMBUS LANDED."

BOYS' AND GIRLS' BOOKSHELF

COMPLETE EDITION

PARTIAL LIST
of EDITORS *and* CONTRIBUTORS

Hamilton Wright Mabie
Rev. George E. Reed
Charles Welsh
Andrew Lang
Howard Pyle
Carolyn Wells
Tudor Jenks
John Burroughs
George S. Bryan
Daniel E. Wheeler
Rev. John Talbot Smith
Joseph H. Adams
Ralph Henry Barbour
Ernest Thompson Seton
L. Frank Baum
Bertha Johnston
Jack London
John H. Clifford
Morgan Shepard
(John Martin)

VOLUME FIFTEEN
BOOK OF WONDERS *and* CURIOUS THINGS
(PART I)

THE UNIVERSITY SOCIETY
NEW YORK

Copyright, 1912, by
THE UNIVERSITY SOCIETY Inc.

PARTIAL LIST OF EDITORS, AUTHORS, AND ILLUSTRATORS WHOSE WORK APPEARS IN THIS PUBLICATION

CHARLES WELSH,
Author of "The Right Reading for Children," "Stories Children Love."

REV. JOHN TALBOT SMITH,
Director of the Catholic Summer School of America and Author of "The Prairie Boy," etc.

MORGAN SHEPARD (JOHN MARTIN),
Writer of illustrated letters to children.

REV. GEORGE E. REED,
Ex-President of Dickinson College.

JOSEPH H. ADAMS,
Editor of "Harper's Practical Books for Boys."

RALPH HENRY BARBOUR,
Author of "The Crimson Sweater" and other books for boys.

L. FRANK BAUM,
Author of "The Wizard of Oz," "Queen Zixie of Ix" and other children's books.

KATHARINE N. BIRDSALL,
Formerly Associate-Editor of "The Children's Magazine."

J. G. BROWN,
Painter of Child-Life.

JOHN BURROUGHS,
Naturalist and Author.

ELLIS PARKER BUTLER,
Author of "The Incubator Baby," "A Thin Santa Claus," etc.

LAURA E. RICHARDS,
Author of "When I Was Your Age," "Five-Minute Stories," etc.

REV. JAMES M. FARRAR,
Author of "A Junior Congregation" and "Little Talks to Little People."

REV. WASHINGTON GLADDEN,
Author of "Santa Claus on a Lark," "Social Salvation," etc.

MARGARET JOHNSON,
Illustrator, and Author of "A Bunch of Keys," etc.

CHARLOTTE BREWSTER JORDAN,
Author of "Mother Song and Child Song," etc.

EMILIE BENSON KNIPE,
Illustrator, and Author of "Little Miss Fales," etc.

JACK LONDON,
Author of "The Call of the Wild," "The Seawolf" and other stories.

LUCY FITCH PERKINS,
Illustrator, Decorator, and Author of "A Book of Joys," "The Goose Girl," etc.

HOWARD PYLE,
Illustrator, and Author of "Otto of the Silver Hand," "Robin Hood" and other young folks' books.

HAMILTON WRIGHT MABIE,
Associate-Editor of "The Outlook" and Author of "My Study Fire," "Works and Days" and other volumes of essays.

ERNEST THOMPSON SETON,
Author of "Wild Animal Play for Children," "Two Little Savages," etc.

HARRIET PRESCOTT SPOFFORD,
Author of "Hester Stanley's Friends," etc.

JASMINE STONE VAN DRESSER,
Author of "How to Find Happyland," etc.

CAROLYN WELLS,
Author of "Folly in Fairyland," the "Patty" books, the "Marjorie" books, etc.

TUDOR JENKS,
Author of "Boys' Book of Explorations," "Electricity for Young People," etc.

JOHN H. CLIFFORD,
Associate-Editor of "The Young Folks' Treasury," "The Mother's Book," etc.

ADMIRAL ROBERT E. PEARY,
U. S. Naval Officer, Explorer and Author of "Northward Over the Great Ice," etc.

GEORGE S. BRYAN,
Writer and Translator.

CLIFFORD HOWARD,
Author of "Curious Facts," etc.

EDITH M. THOMAS,
Author of "Lyrics and Sonnets," "The [Children of Christmas," etc.

DANIEL E. WHEELER,
Associate-Editor of "The Young Folks' [Treasury," etc.

AMY STEEDMAN,
Author of "In God's Garden," etc.

L. L. WEEDON,
Author of "Bible Stories," etc.

ARTHUR UPSON,
Poet and Critic.

EMILIE POULSSON,
Author of "Nursery Finger-Plays," ["Child Stories and Rhymes," etc.

PAULINE FRANCES CAMP,
Author of "Poems."

MARY V. WORSTELL,
Author, Editor and Lecturer.

EDWIN L. SABIN,
Author of "When You Were a Boy," etc.

MARTHA BURR BANKS,
Author of "Dame Dimple's Thanksgiv- [ing."

DAVID KILBURN STEVENS,
Author of "Lays of a Lazy Dog."

F. S. CHURCH,
Illustrator.

WILLIAM OLIVER STEVENS,
Author of "The Young Privateersman."

CHARLES FREDERICK HOLDER,
Author of "Stories of Animal Life," ["The Boy Anglers," etc.

E. W. KEMBLE,
Illustrator; Author of "Kemble's Sketch [Book," etc.

CONSTANCE C. HARRISON (MRS BURTON HARRISON),
Author of "Old-Fashioned Fairy Books," ["Folk and Fairy Tales," etc.

DAY ALLEN WILLEY,
Journalist and Magazine Writer.

CHRISTINE TERHUNE HERRICK,
Author of "Cradle and Nursery," "What [to Eat," etc.

ROBERT WILLIAMS WOOD,
Professor of Experimental Physics in Johns Hopkins University; Author of "How to Tell the Birds from the Flow- [ers," etc.

EDWARD F. BIGELOW,
Naturalist; Editor of "The Guide to Nature" and Author of "The Spirit [of Nature-Study," etc.

EDMUND J. SAWYER,
Natural History Writer.

FRANK L. CHAPMAN,
Curator of Ornithology, American Mu- [seum, and Editor of "Bird-Lore."

JAMES C. BEARD,
Illustrator, and Author of "Little Workers," "Curious Homes and Their [Tenants," etc.

THOMAS H. KEARNEY,
Of the Bureau of Plant Industry, U. S. [Department of Agriculture.

ERNEST INGERSOLL,
Author of "Wild Life of Orchard and Field," "The Life of Mammals" and [other works on natural history.

MARY DAWSON,
Author of "The Book of Frolics for All [Occasions."

GEORGE ETHELBERT WALSH,
Author of "The Mysterious Beacon [Light," etc.

BERTHA JOHNSTON,
Editor of "The Kindergarten Magazine" and Author of "Home Occupa- [tions for Boys and Girls."

EDWIN W. FOSTER,
Author of "Carpentry and Woodwork," [etc.

W. S. CAMERON,
Natural History Writer.

SILAS ALPHA LOTTRIDGE,
Author of "Animal Snapshots and How [Made.

WILLIAM LOVELL FINLEY,
Author of "American Birds Studied [and Photographed from Life."

A FOREWORD

DEAR BOYS AND GIRLS:

When you were little—that is, when you were VERY LITTLE—did you ever look up into the sky and say to yourselves the words of the good old verse:

> "TWINKLE, TWINKLE, LITTLE STAR;
> HOW I WONDER WHAT YOU ARE!
> UP ABOVE THE WORLD SO HIGH,
> LIKE A DIAMOND IN THE SKY"?

If you said those words THOUGHTFULLY, you wanted to know many things about the stars—how *far* away they were; what they were *made* of; were they *worlds like ours;* did *men* and *animals* live on them; did they *ever* stop *twinkling*.

I am not quite sure, Boys and Girls, but I think that if you REALLY WONDER about anything you WANT to KNOW about it. If you wonder why the watch ticks, you want to have it opened so that you can *see the wheels go round.*

It seems to me that I like every kind of boy and girl. I once knew a boy who had RED HAIR and FRECKLES and a BIG NOSE, but he was so CUTE and SO FOND OF WORK AND PLAY that I liked him ever so much. After we became well acquainted *he asked*

me lots of questions, and then I liked him MORE than EVER. And do you know that boy became a GREAT MAN. I "wonder" if every boy who has a big nose doesn't AMOUNT to SOMETHING when he grows up!

Some time, if the publishers will let me, I will tell you about A LITTLE GIRL I knew. She looked JUST like a JAPANESE girl. She had a *flat* nose, *queer* eyes, and *coarse* black hair—but *my* how I LOVED her!

When I began to think about that boy with the big nose, I was going to tell you HOW MUCH I like ANY BOY that WONDERS about things and ASKS lots of questions. You remember that ABRAHAM LINCOLN, when he was just a little boy and everybody called him Abe, asked so many questions that his father *scolded him for it.* Oh, yes, I like a boy who wonders why his BICYCLE keeps upright; why COAL burns and STONES do not; what makes his HEART beat; how ANIMALS talk to each other; and a thousand other things.

I am sure that the boy or girl who wonders "REAL HARD" is on the road that leads to KNOWLEDGE and WISDOM. This road may be a long one, but it is a pleasant way to travel, and at its end is a BEAUTIFUL CITY. If you really wonder, you will think and ask questions and study books.

I suppose every boy likes the BOY SCOUTS. Perhaps every GIRL likes the Boy Scouts, or at least ONE of them. Well, when I have time I am going to start a NEW SOCIETY. It shall be named the WONDER SCOUTS. Both boys and girls may become members. No uniform will be needed. The members will be known

by their BRIGHT EYES, and the BOOKS they read, and the CLEVER QUESTIONS they ask. Every member must wonder about something, and try to find out about it from a book or by asking questions, every day. ALL MEMBERS must ask themselves this question just before they go to sleep at night: "*Have I had a 'wonder' and learned about something to-day?*" If they have not, all members must wonder and learn something before they go to sleep.

Boys and Girls, I am going to MAKE YOU ALL members of this society AT ONCE, whether you wish to join it or not! Tom and Jack, you are now members of this new society. Helen and Mabel, you were taken into membership last week. I forgot to write you about it. *You are all members*—active, thoughtful members, in good standing with ALL DUES PAID.

Don't forget that all little "wonders" lead to LARGER ones and all "wonders" that come to bright girls and boys lead them to THINK and STUDY.

Here are the pledges and by-laws of the great WONDER SCOUTS SOCIETY that has been started with nearly 5,000,000 members:

1. I shall never forget that if I don't wonder about some proper thing every day, I may be fined or expelled from the Society.

2. I agree to try every day to learn something about the things concerning which I have wondered, by asking questions and using the dictionary, cyclopedia, and other books.

3. I realize that I may be expelled from this great and good Society if I permit myself to go to sleep at night without having learned something new during the day.

And now, Boys and Girls, as I have taken you all into full membership in my new Society, I am going to tell you about some of MY OWN WONDERS.

1. This book of WONDERS AND CURIOUS THINGS is a very good book. Will you read it carefully—*I wonder?*

2. Will you read it so as to LEARN and REMEMBER what it teaches ; or will you learn but little from it because you read it in a careless, sleepy, and indolent way—*I wonder?*

3. As I look at all of you Wonder Scout Girls, I am quietly asking myself: will they become BRIGHT, GOOD, HAPPY, and true-hearted girls and women—*I wonder?*

4. How about the Boy Wonder Scouts—will they become BRAVE boys and NOBLE men—*I wonder?*

The publishers asked me to write you a letter and tell you about this volume which they call their BOOK OF WONDERS AND CURIOUS THINGS. But this letter has already run to such a great length that *I must close it.* So, Boys and Girls, if you are ever to know much about this book you must READ it for YOURSELVES—and that would be a VERY GOOD thing for you to do.

Always lovingly yours,

UNCLE GEORGE

CONTENTS

GREAT MECHANICAL MARVELS

PART I

THE BUILDING OF A GIANT LINER

BY W. G. FITZGERALD

ALTHOUGH Ireland is supposed to be a very poor country, it is a curious fact that in her city of Belfast is built a larger percentage of magnificent ocean liners than anywhere else in the world. For there is one "yard" in that city turning out with monotonous regularity great steamships like the *Adriatic* of the White Star line. The gross tonnage of this enormous ship is 25,000, and she transports nearly 4000 souls across the broad Atlantic in less than a week.

Imagine what a hive of industry and machinery must be the place where such colossal ships are born. Think of 14,000 men, assisted by a whole world of thunderous engines, extending over eighty acres, and all at work upon gaunt skeletons which in a few brief months will be floating palaces of the sea!

In one year eight of these giants were launched, and they developed altogether the power of more than 100,500 horses. Most of them have nine decks, and carry about 3000 passengers and a crew of 500 or 600. Glance for a moment at the *Adriatic,* which, when built, was the largest vessel in the world.

Her length—about 750 feet—exceeds that of two towering skyscrapers placed one on top of the other; and her funnels, being 24 feet in diameter, would easily admit a couple of full-sized trolley-cars driven abreast throughout their whole length of 155 feet! Passengers taking their morning stroll on deck will understand that a circuit of the ship three and a half times means covering almost exactly a mile.

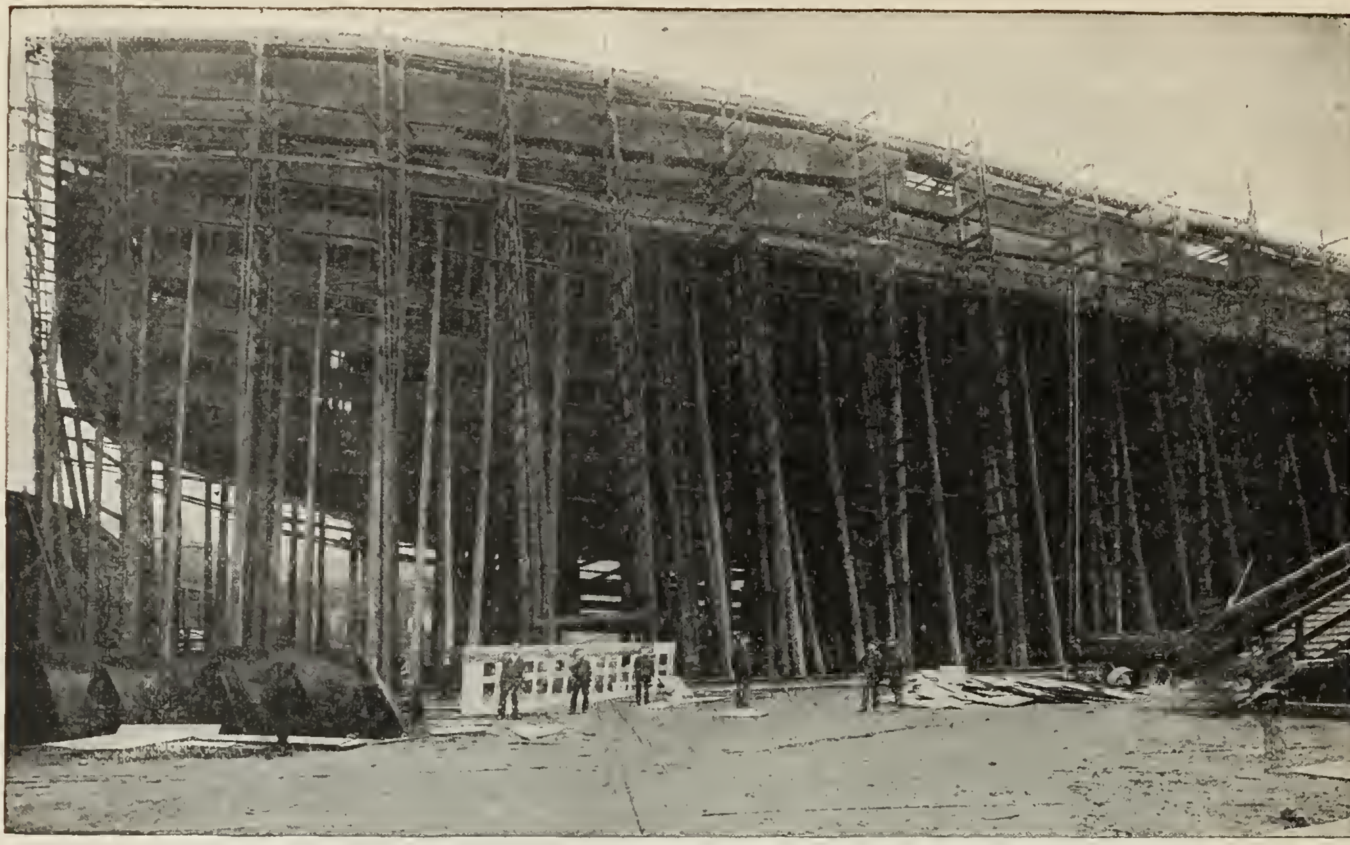
As the vessel lies on the ways, one obtains an admirable idea of her vastness. It is like looking up at one of the pyramids; only, instead of rising from a desert, the towering hull commands one of the busiest industrial hives of men. Stand on the forecastle in the very eyes of the leviathan, and the ground is nearly 100 feet below. A confused hum floats up from the joiners' and blacksmiths' shops, for all are busy upon the giant carcass which, even in this bare state, weighs over 16,000 tons—even without engines, boilers, and palatial accommodation for passengers.

A full company of passengers, the water in her boilers, her stores, and her 7000 tons of coal, raise the ship's weight, without cargo, to 45,000 tons. The lowest deck of all is known as the "lower orlop"; then, rising tier by tier, we have the orlop, lower, main, upper, shelter, promenade, upper promenade, and boat—nine decks in all. A ship like this appears almost unsinkable, being divided into no less than 175 separate water-tight compartments.

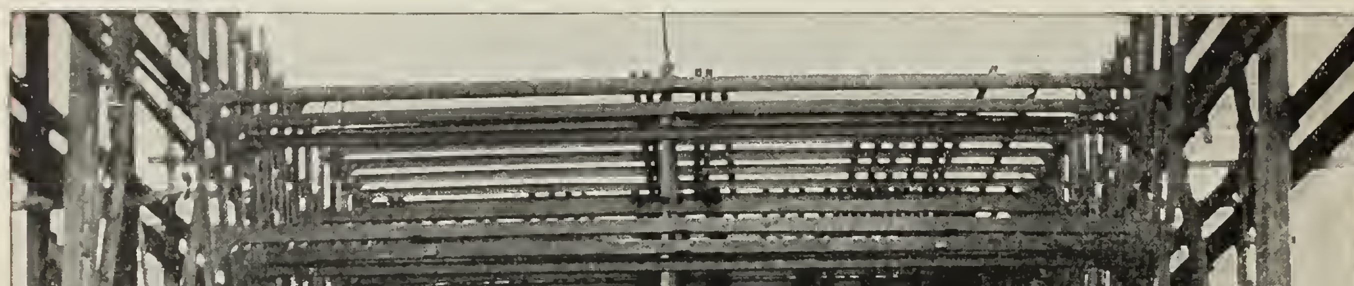
Her vast ribs are covered with 26,000 steel plates, the largest 40 feet long, and weighing about five tons. To fasten these to the mighty structural framework took 4,500,000 rivets, and some of these weighed three pounds. The rudder alone weighs 65 tons, or, including the castings for the steam, stern-post, and shaft-bracket, 280 tons. Three anchors of ten tons each are carried to control the giant, and each is provided with 1800 feet of cable, made up of 22-inch links, the iron in which is nearly four inches in diameter. Think of a chain of which every link weighs a hundredweight and a half!

There are even electric elevators for both passengers and mails. As to the electric light, there are over 5000 lamps fed by 200 miles of cable. One novel feature is a kind of central inquiry bureau which may be rung up by any one of the thousands of passengers upon any matter on which information is desired. Is it any wonder that such a ship would require a strength of 70,000 horses to drive her across the ocean?

And in the place where such ships are built there is also a kind of marine hospital where sur-



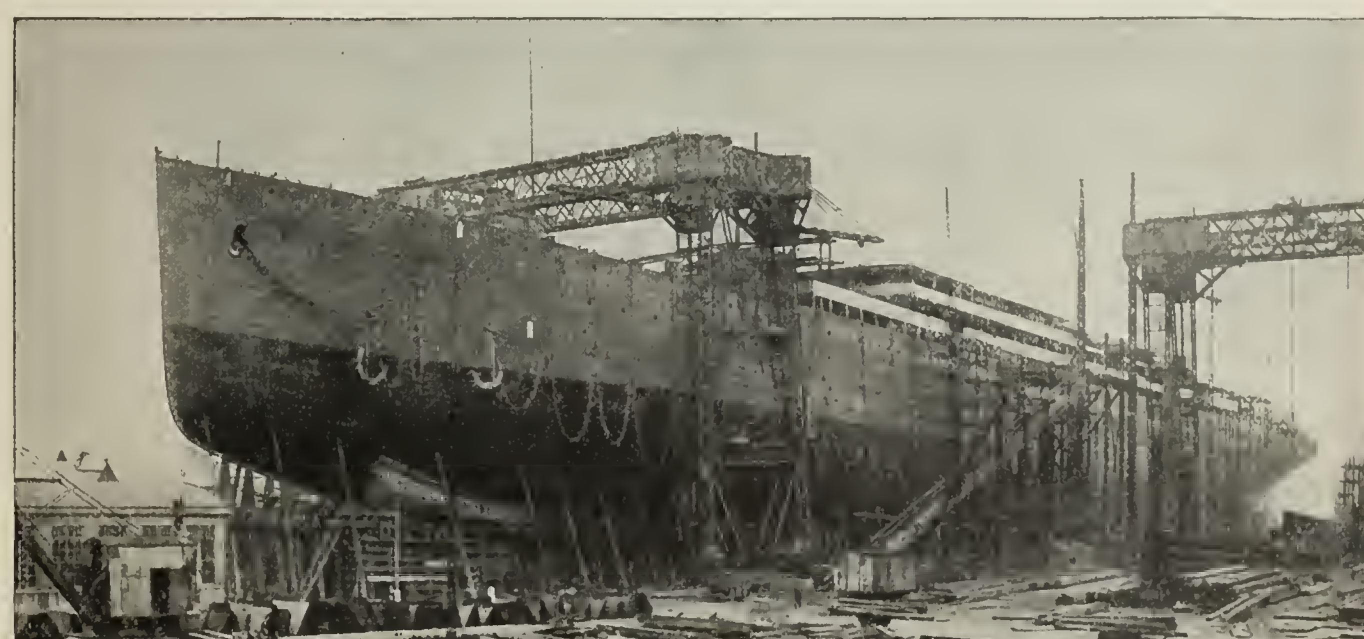
BOW VIEW OF THE "ADRIATIC." COATING HER SIDES WITH 26,000 STEEL PLATES.



A VIEW OF THE SHIP PARTLY FRAMED, AND SHOWING THE TANK TOP PLATING.

THIS IS NOT A RAILROAD BUT MERELY THE PROMENADE DECK OF THE "ADRIATIC" IN COURSE OF CONSTRUCTION AT BELFAST.

gical operations on a vast scale are conducted. The great Indian liner *China,* for example, was a patient. She sank in the Red Sea near Perim, and her bottom had to be entirely reconstructed. Another case was the *Paris,* renamed the *Philadelphia.* She had run onto the dreaded Manacles



THE COMPLETED HULL ON THE STOCKS READY FOR LAUNCHING.

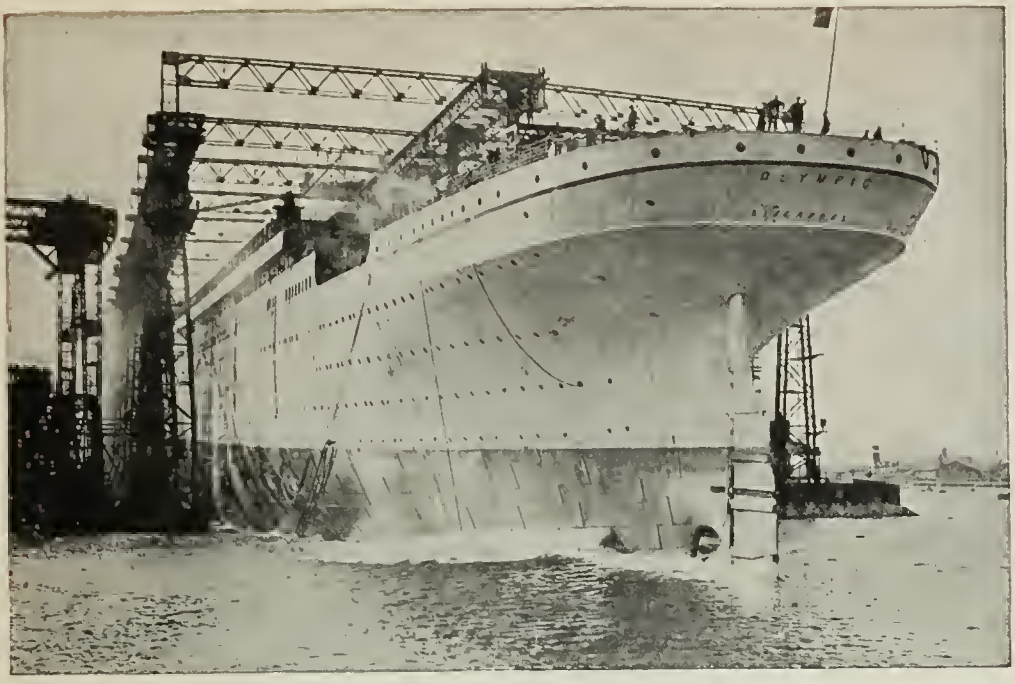
THE LAUNCHING OF THE STEAMSHIP "ADRIATIC;" LEAVING THE WAYS.

Rocks off the coast of Cornwall, England, and required an entirely new stern, as well as new engines and boilers.

Again, the South African liner *Scot* was taken into dock in Belfast, cut clean into two parts, and an additional length of 50 feet built into her body amidships. A similar operation was performed on the Hamburg-American liner *Augusta Victoria.*

An incident showing the value of these watertight compartments was that of the steamship *Suevic,* which ran upon the rocks off the Lizard on the English coast in 1907. The forward part of the vessel was badly crushed, but the watertight compartments prevented the water from filling the vessel. After the high sea had abated, the rivets of the framework and outer plates were loosened, and, assisted by a blast of dynamite, the *Suevic* was separated into two parts, the forward one third remaining on the rocks, while the after two thirds *proceeded to Liverpool under the vessel's own steam.*

THE "ADRIATIC" AT SEA.



THE STERN OF THE "OLYMPIC," SHOWING THE RUDDER.

THE WORLD'S LARGEST STEAMER

THE *Vaterland*, which was taken over by the United States navy during the Great War as a transport, under the name of the *Leviathan*, is the largest vessel that has ever been built. It has a displacement of sixty-two thousand tons and the walk up and down its length is a distance of over one-third of a mile.

The White Star liner *Olympic* and the twin ship, the ill-fated *Titanic*, were not so large as this, but they contained many radical improvements, and provide for 2,500 passengers, while the crew numbers nearly one thousand men. The mighty engines are of 4,500 horse-power and are of two kinds, known to engineers as the reciprocating and the turbine. Both ships were launched from Belfast in Ireland, which with Glasgow, Philadelphia, and

THE TWIN STEAMERS "OLYMPIC" AND "TITANIC," IN THEIR CRADLES OF STEEL AT BELFAST.

Seattle, is one of the world's greatest shipbuilding centers.

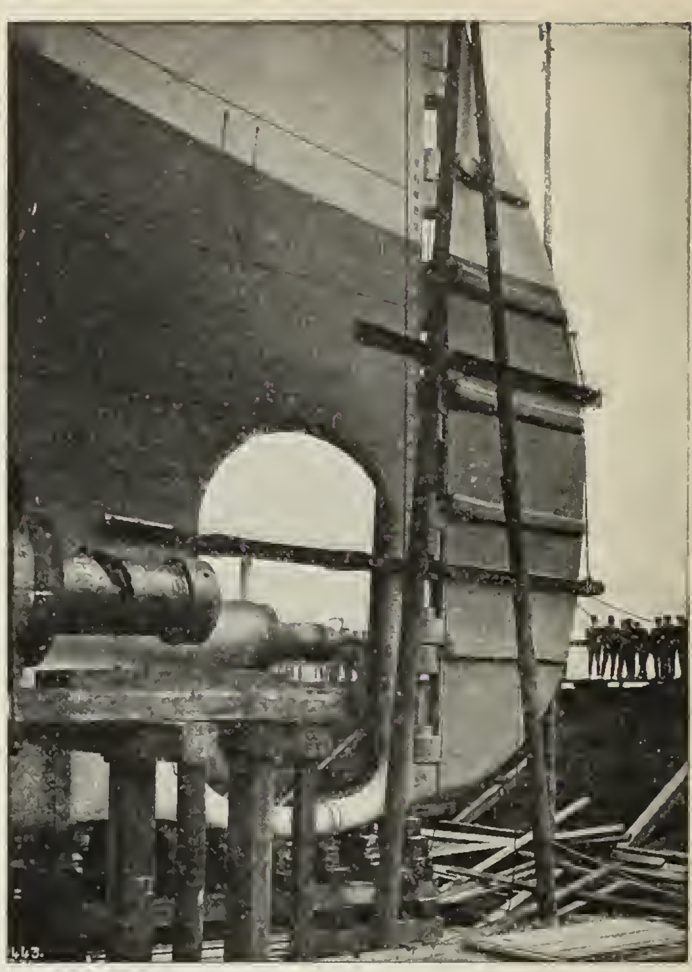
The *Olympic* was also used during the war as a transport, carrying whole regiments of soldiers across the Atlantic in a single voyage.

This huge *Olympic* in general appearance resembles the *Mauretania* and the *Lusitania*, built not long before.

It may help us to realize the *Olympic's* great length of eight hundred and eighty-two and one half feet if we compare it to the Metropolitan Tower in New York, above which, if set up on end, she would extend one hundred and eighty-two feet. She is twice as long as the height of the dome of St. Peter's at Rome, and equals in length the total drop of the famous Bridal Veil Fall in the Yosemite Valley. If she and her sister ship, the *Titanic*, were placed end to end under Brooklyn Bridge, they would completely block the East River and extend one hundred feet over each shore. It is also interesting to note that the length of this immense ship is four times the height of Bunker Hill Monument.

Since the advent of the *Great Eastern* in 1858 no steamer has created such general interest as the *Olympic*, not only on account of her surpassing size, but also because of the immense forward steps thus marked in other lines of marine accomplishment, the outcome of many centuries of conflict with the sea.

In both the *Olympic* and the *Titanic* three million steel rivets, weighing in all 1200 tons, have been employed to bind the massive steel plates, insuring the greatest stability; and the rudder of each vessel weighs 100 tons, yet will be moved by electricity almost as lightly as a feather.



A NEAR VIEW OF THE RUDDER.

Because of the enormous size of the ships, the accommodations, both as regards the several public apartments, including tennis-courts, sun-parlors, swimming-pools, etc., and the passenger staterooms, are exceptionally spacious, while the beauty and luxury of the appointments surpass anything of the kind heretofore attempted.

THE "OLYMPIC" AFTER THE LAUNCHING.

NATURE GIANTS THAT MAN HAS CONQUERED

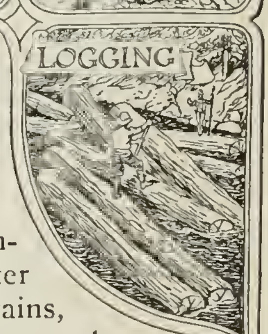
BY RAYMOND PERRY

MANY centuries ago man's achievements were limited by the strength of his body, because he did not know how to make the forces of nature work for him. He knew that these forces existed. The wind, the rain, the lightning, all seemed to him the acts of great giants of the earth and sky—or even strange, powerful gods whom he worshiped through fear.

Ages passed before man learned that these forces were as willing to work for as against him, if only he could learn the secrets of control.

The history of the world is largely the story of how man has obtained increasing mastery over these nature giants and used their powers in the tasks of progress.

Wind is the first nature giant that man tamed to his use. Probably, from seeing a tree swayed by this mighty power, man came, at last, to reason that if the tree was aboard a boat, the boat would move in the direction of the wind; so he made a mast from a tree-trunk, and rigged up some rude sail from skins of animals, to take the place of leaves, and found that he could go much faster and farther than with his paddle alone. Gradually, then, he learned also, by means of "tacking," to sail in any desired direction, no matter which way the wind blew. Thus he had discovered the principle used by every sailing-vessel since. Later, he devised the windmill for grinding grain and drawing water. The kite makes use of the wind power and has suggested the aeroplane which man has now made possible through later discoveries. The vacuum cleaner is another way in which the power of air in motion is used. As yet, man cannot perfectly control the wind giant, for cyclones sometimes do great damage on land and sea; but even this occasional danger may yet be subdued.



NATURE GIANTS THAT MAN HAS CONQUERED

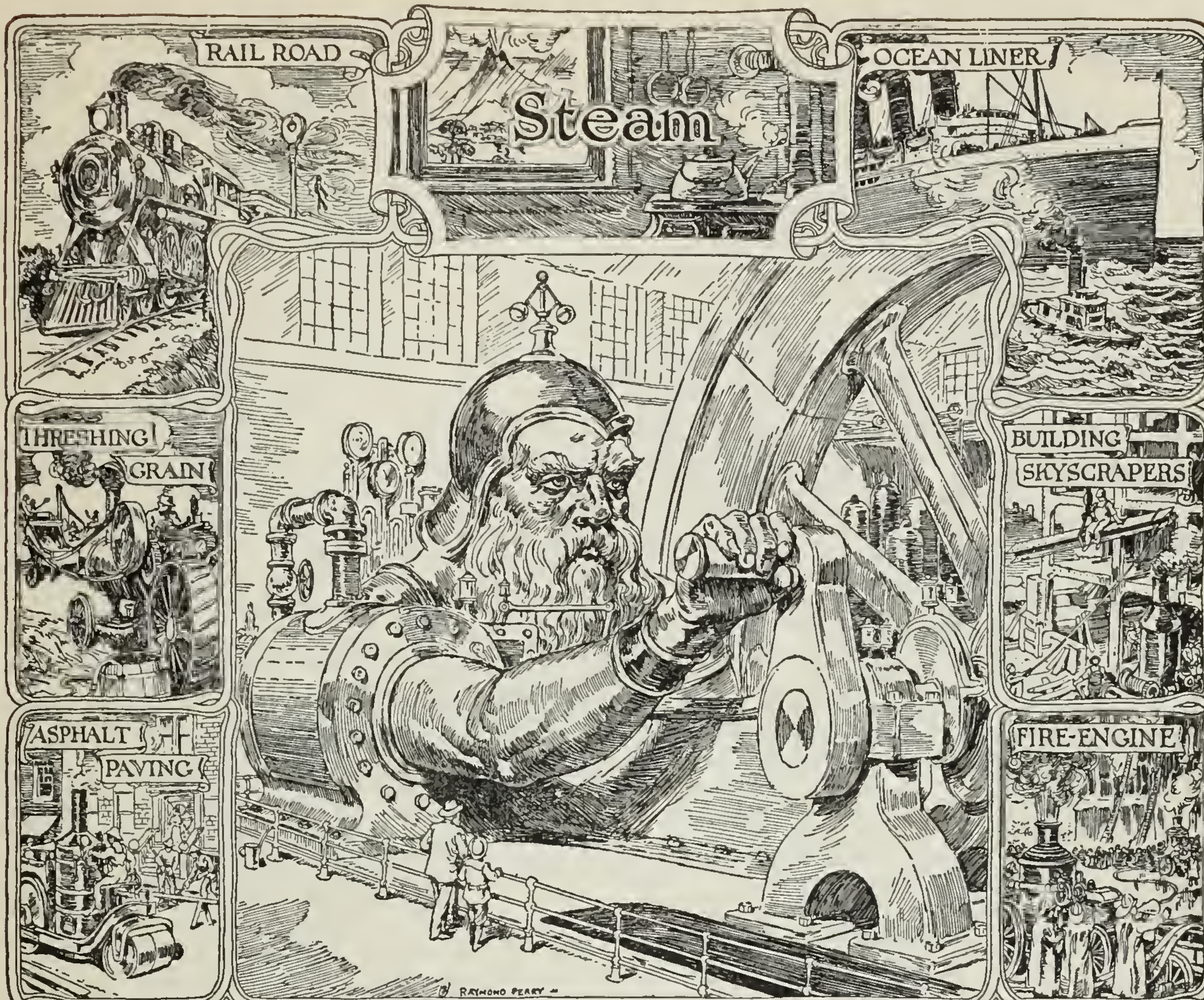
BY RAYMOND PERRY

GIANT NO. 2—WATER-POWER

One of the greatest giants that man has tamed is the Wind. The second nature giant that man learned to control was the power of flowing water. We all know that water rises from the ocean as vapor and, dropping as rain on the mountains, makes its way in rivers to the ocean again. The explanation is simple enough, but when we see a mighty waterfall like Niagara, we realize at once that we are in the presence of a powerful giant who can do the work of armies for us, if properly harnessed. But it was long before man learned how to do this.

Up to that time each one had to grind his own grain, a little at a time, by rolling it between two flat stones; but when he learned the use of the water-wheel, he was able to grind with larger stones, such as he himself could not even move, and produce enough meal for his own use and a whole village besides. And now, to crown all, we have the turbine, which takes vastly greater power from the passing water.

The manufacturing industries have made our country famous the world over, and the giant water-force is doing its full share in turning the wheels. We can also see the power of water in use in a canal-lock by means of which a boat may be taken uphill; and in hydraulic mining where it digs the dirt and washes out the gold at the same time. The modern systems of sanitary plumbing, safeguarding the health, and of irrigation, by means of which vast tracts of desert lands are made to bloom, both depend upon the power of falling water.



GIANT NO. 3—STEAM

One of the most famous nature giants is the power of steam as seen, for instance, in volcanoes like Mount Vesuvius. Ocean water finds its way, through fissures in the sea-bottom, down into the heated caverns, and is there converted into steam, which escapes through the crater of the volcano, carrying with it molten rock and gases. Herculaneum and Pompeii are two cities buried centuries ago by such eruptions. Earthquakes and tidal waves are also due to the power of steam convulsing the regions far below the earth's surface. Watt, an Englishman, first discovered the power of steam by noticing that the cover of his mother's boiling tea-kettle was frequently pushed up by the steam in its effort to get out. This resulted in his making the first steam-engine. Since Watt made the first engine, improvements have been made in all its parts, such as flues in the boiler, safety-valves, governors, and devices to save the power yet remaining in steam already partially used. To-day we have the swift locomotives drawing palatial passenger-trains from coast to coast, the powerful "Mogul" engines for long freight-trains, and the massive stationary engines for factory use. On the sea great ocean liners are making new speed-records every year. Threshing is done by steam-machinery, and in the city the steam-roller helps to pave the streets, the steam-hoist helps to build steam-heated sky-scrapers, and steam fire-engines protect the lives within these buildings. It may seem strange, but it is this same hot steam that gives us cooling drinks, cooled theaters, and even skating in summer by operating steam-engines that drive powerful ice-making machines.

NATURE GIANTS THAT MAN HAS CONQUERED

BY RAYMOND PERRY

GIANT NO. 4—THE EXPLOSIVE

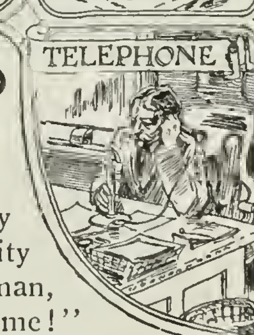
THE fairy story of a large and powerful genie confined in a small jar, is no more wonderful than is the true story of a bit of powder packed in a cartridge; when the powder is exploded, it propels the bullet far and with terrific speed. A Chinaman first discovered the power of explosives when he invented gunpowder, and it has proved to be the greatest of all the forces that have changed the maps of nations. Explosives so powerful have been discovered now that no gun can be made strong enough to be discharged more than a comparatively small number of times; and there are machine-guns, submarine mines, and torpedoes—engines of destruction so powerful that no battle, either on land or sea, could last more than a few hours. Indeed, it is predicted that soon no two nations will dare to go to war, so terrible would be the consequences to themselves and to the rest of the world.

While explosives are needed less and less for war than formerly, they are used more and more in the victories of peace. When the genie was let out of the jar, he built great palaces for his master and transported him great distances by land, by sea, and in the air; and that is just what the Giant Explosive is doing to-day for man, his master. The power of dynamite is blasting rock for the foundations of sky-scrapers and bridge piers, and boring tunnels through the solid mountain; while gasolene, the new explosive, is used for transportation, in automobiles on land, in motor-boats in the water, and in aëroplanes in the air; thus finally accomplishing the dream that man has cherished for centuries,—the marvel of human flight.

NATURE GIANTS THAT MAN HAS CONQUERED

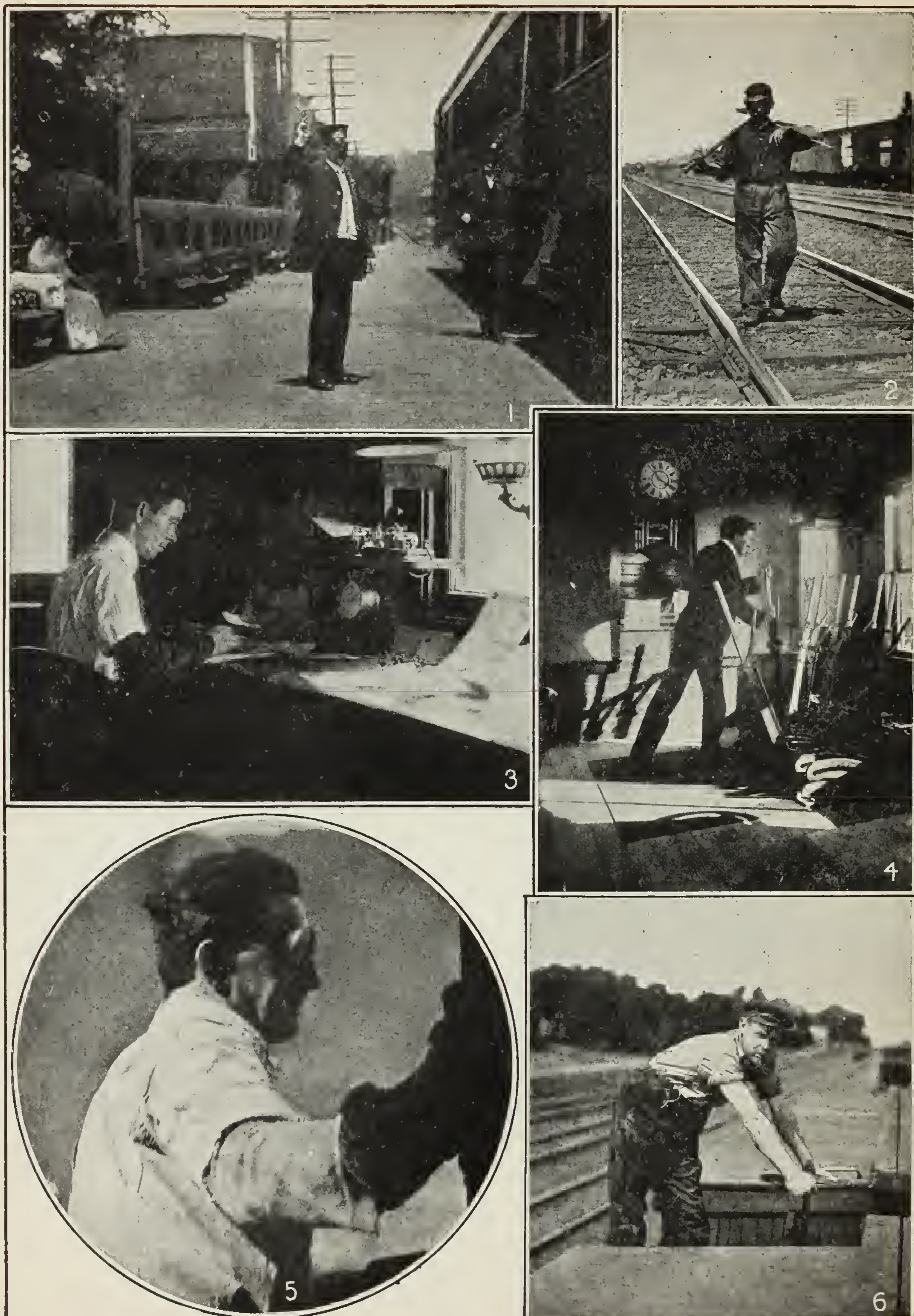
BY RAYMOND PERRY

GIANT NO. 5—ELECTRICITY



Of all the nature giants that man has conquered, Electricity is the most mysterious and interesting. Lightning is Electricity revealing himself in nature, as though he were calling to man, "See, I am all about you, anxious to be used; come and take me!"

And so he has been impatiently calling to man from the most ancient times, but has always been misunderstood and neglected until lately. Electricity is a big, noisy giant at large, and badly spoiled, for he wants lots of coaxing and petting; but treat him rightly and he settles down to his work as amiably as you please. You can hear him humming to himself in the big dynamo power-house, where he sends out the currents that drive the trolley-cars, and those that light the streets and houses through innumerable arc and incandescent lamps. Every American boy may feel proud that America has always led the world in the subjugation of Electricity. Franklin's experiments opened up the possibilities, and other Americans have been developing them ever since. Morse invented the telegraph and Bell the telephone, and their use has brought the people of the earth closer together. By taking advantage of the invisible lines of electric conductors in the air—the ether, rarer even than the air itself—we have been enabled to telephone and telegraph without wires. Already hundreds of lives have been saved through messages sent from or to ships at sea. When the boys of to-day are grown-ups they will probably look back upon the present as but the beginning of the wonders promised to humanity by the giant Electricity.



1. THE CONDUCTOR AND THE TRAINMAN. 2. THE TRACK-HAND. 3. THE STATION-AGENT. 4. THE SIGNAL-TOWER OPERATOR. 5. THE ENGINEER. 6. THE BRAKEMAN.

THE GREAT WONDER OF A RAILWAY TRAIN

You must have stood some day in a country road, perhaps in a quiet place far from any town, and watched a train rush past. There is really nothing in the world more thrilling to see than that, especially if it is dark, and the train flies past in a flood of light, like a giant who possesses the earth. That train started from a great city; it flies through towns and villages, past fiery furnaces and smoky factories, through quiet fields where cattle are grazing and birds are singing, on into another busy city that lies ahead.

This wonder of the world, the railway train, is one of the greatest triumphs of man. It began with a kettle steaming on the hob—with a man who started thinking for himself about the steam, and wondering what could be done with it. That thinking man has changed the world for you and me, and when we go to the seaside for our holiday, or come to New York to see the great stores, or go from town to town to see our friends, we owe our pleasure very largely to a man who sat by the fire a hundred years ago watching a kettle steam.

Perhaps you have not thought, when quietly sitting in a railway carriage, that you can be safe and happy at such a time only because thousands of men are wide awake and looking after you. It is not enough for the driver to be always looking out; it is not enough for the fireman to keep the fires burning. If nobody did anything else than that, we should never get anywhere at all, and no railway would be safe. The men in the signal-boxes must attend to the signals. The track-walkers must see that the line is safe. The man at the switch where the lines join must see that the switch is properly set. The man who makes the time-tables must see that two trains are not at the same place at the same time. The men in the station must be ready for the train when it stops. Somebody must see that the tunnels are free, that the bridges are safe, that there is water for the engine when it is wanted. Every bit of every railway should be examined every day.

And so hundreds of thousands of men are kept busy all day long, watchful every moment, listening, thinking, writing, telephoning, running, shouting, working at a hundred things, in order that we may ride comfortably in the train.

A hundred years ago there was not a single train in the world, and there are still many old people who have never been in a train. There are some people who have never *seen* a train. The railway is yet young, but it has grown quickly because it is the first thing that men need when a country begins to grow. Thousands of trains are always running, carrying thousands of people to and fro, and it is a wonderful thing to think that the power which drives them is the same power that makes a violet grow. If there were no sun there would be no trains, because there would be no fuel; and if there were no fuel there would be no steam to drive the giant engines on their way.

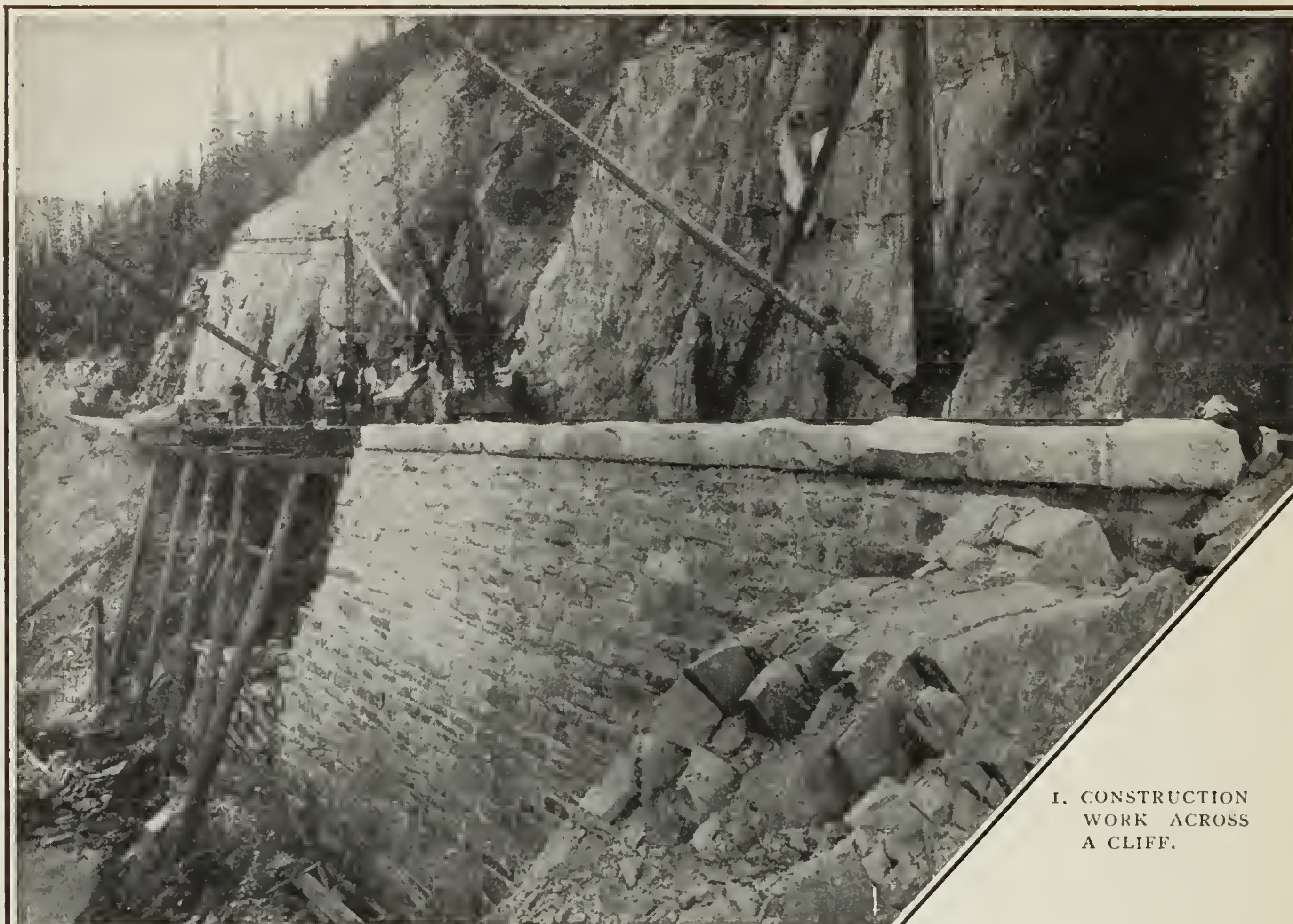
THE RUNNING OF A TRAIN

When railways were new, as many a man still living distinctly remembers, a train could not be stopped unless a brakeman on each car put on the brakes with his utmost strength by turning a little wheel like those that are still kept near the platform-rail. So, when coming near a station, the engineer would blow a signal, the brakeman on each car, using all his strength, would put on the brakes by hand, and gradually the train would stop, often with a bump that threw the passengers forward in their seats.

To-day, all brakes are moved simply by turning a little handle in the engineer's cab. This is done by having the brakes drawn against the wheels by powerful springs, then pushed away by air compressed in tubes underneath the car. The air-pressure is kept on to hold brakes from the wheels until necessary to slow or stop the train. Then the engineer, turning the little handle, lets the air out of the tubes, the springs set the brakes gradually as the air escapes, and the train comes gradually to a standstill without jarring.

This gives quick and sure control of a train, no matter how heavy. It is also the greatest safeguard against accidents caused by trains breaking apart. As the cars separate, the air-tube also parts, its air escapes, and the brakes are set, bringing car and train to a standstill.

Early trains were wasteful of power. Once the steam used to drive the wheel escaped into the air. Now the steam is used first in a large cylinder, then escapes to a smaller one, where it is used again and so does much more work with less waste of fuel.



1. CONSTRUCTION WORK ACROSS A CLIFF.

2. SIGNAL - TOWER (SHOWING PIPE-RODS FOR CONNECTING SIGNALS AND SWITCHES).

3. MOUNTAIN ENGINEERING (KICKING HORSE CAÑON, C. P. R. R.).

4. JUNCTION PROTECTED BY SEMAPHORES INTERLOCKED WITH SWITCHES.

The burning of coal is much hastened by having mechanical ways of blowing the fire, instead of depending only upon the draft from the smokestack. So the old big high smokestacks, no longer useful, are replaced by small ones which are quite sufficient, because the fire is blown by machinery.

Another valuable improvement of recent years is that which permits officials of a road to talk with trainmen while the train is in motion. This is done by electricty taken from the wires running along the track, conducted within the car, and used in telephoning or telegraphing.

Something has been said already of modern signals to safeguard tracks, but these are of so many kinds and so wonderful in construction that great volumes would be necessary to explain the different kinds.

RAILWAY DISCIPLINE

Railway management has become a science and an art only to be understood by men who spend their lives in learning some of the branches. Yet the whole force of railway men is under discipline like an army, divided into different departments, each with its officers and workers, and all responsible to the few managers at the top of the system. Even the mere business bookkeeping, to show what is done with every cent of money expended, with every bit of property, and so on, requires an army of clerks, and forms a vast business in itself.

Before anything is done outdoors, whether it be the running of a train, the building of a bridge, or the opening of a new station, every bit of the work must be foreseen, planned, and arranged for by engineers, drawers of plans, and accountants. Even the time-tables by which each of us knows just when to expect the train he wishes to take, is the result of hours upon hours of careful work done in order that each train may have its own schedule, each station the stops to which it is entitled, each business house a chance to use the freight-cars it may need, and all so planned that none of the hurrying trains shall, if all goes well, interfere with one another. All this is planned out on a great board, by the use of pegs and strings, so that the diagram will show just where each train is to avoid every other. Putting on a single extra train requires sometimes the upsetting of the carefully arranged plan.

Little boys sometimes are filled with admiration and wonder when they see the engineer driving a great locomotive. But though it seems more romantic, the engineer's work does not compare in difficulty with that of many a quiet worker in the railway offices, whose day is spent in studying figures or handling plans and drawings.

RUNNING THE FAST EXPRESSES

BY GEORGE ETHELBERT WALSH

When the Twentieth Century Limited, or some other fast railway-train, rushes across the country at the rate of seventy miles an hour, making mile-posts and trees skip by in fantastic disorder, the mind of many a passenger is troubled by a question that continually arises at every sharp sway or jolt of the cars: "Is there not danger in such rapid traveling?"

In his seat forward the engineer would reply grimly to this question with a negative shake of the head; and the general superintendent of the road, or the train-despatcher in his office at headquarters, would second this answer with a more emphatic "No."

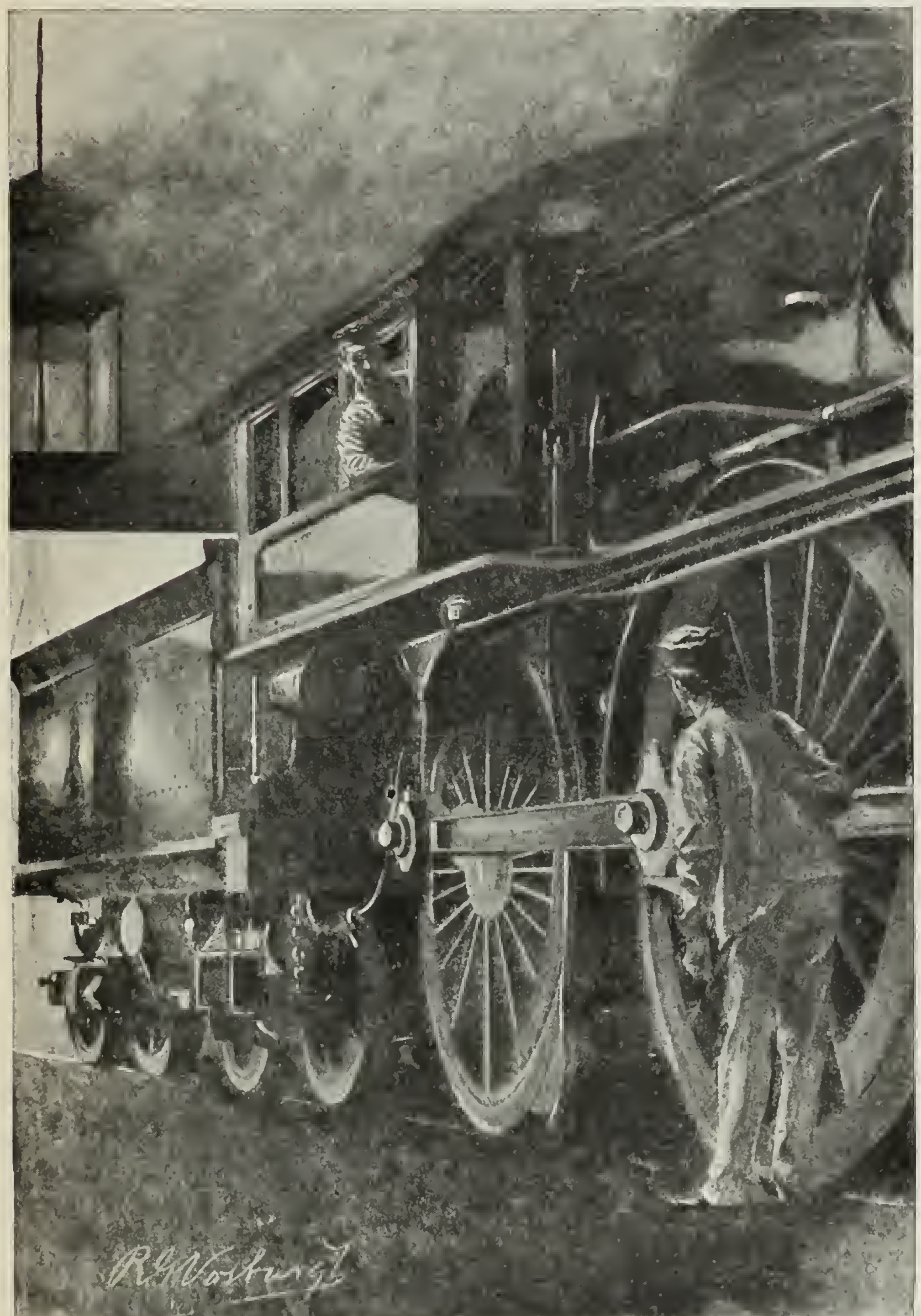
But why? According to all the mathematical rules we learned at school and college, the faster a moving body swings along a certain course, the more difficult it is to swerve it from its path, and the more terrible is the collision if it should strike an obstacle.

Why, then, is not rapid running more dangerous than slow? "Because the engines used for this service are larger, better equipped, and better cared for than any others," the engineer would reply. "They are provided with every modern device to prevent accident; and though they fairly fly along the track, they are never beyond our immediate control. And then—we 're more wide-awake and alert for danger."

"The danger is less for the reason that everybody along the line is looking out for the rapid fliers," would say the train-despatcher. "They have the right of way, and we always clear the tracks for the expresses. They are special favorites, and we give extra careful attention to them."

For verification of these answers let us follow the two immediately responsible parties in their day's work—the engineer and the train-despatcher.

The former comes down to his post of duty nearly an hour before his train is scheduled to leave. All night long in the roundhouse the engine has been carefully watched; a wiper has spent the whole night rubbing down the panting, snorting iron horse until every rod and cylinder shines like gold or silver; the banked fire has been kept going, so that a little steam has been always in the boxes; and before he left at night the fireman put everything in perfect order inside the cab. The fireman appears first in the morning, and inspects the work of the roundhouse men; and if any part is not satisfactory, he makes it so. The engineer makes his inspection after the fireman, and thoroughly and carefully examines every part. All the bearings are then oiled, and the oil-cups are filled with oil. Next, the engine is run out of the roundhouse and tested. Fifteen minutes before the time to start, the engine is coupled to the train, and the steam- and air-brakes are tested.


IN THE ROUNDHOUSE. GROOMING THE ENGINE.

No race-horse was ever brought to his post better fitted for running the course than is the locomotive of the fast express. In addition to the tests already made, a mechanic goes from wheel to wheel, and upon every one strikes a sharp, resounding blow to ascertain if the wheel and axle are sound. Nuts and bolts are examined. The engineer and fireman are held responsible for the perfect condition of the engine and cars before the start is made.

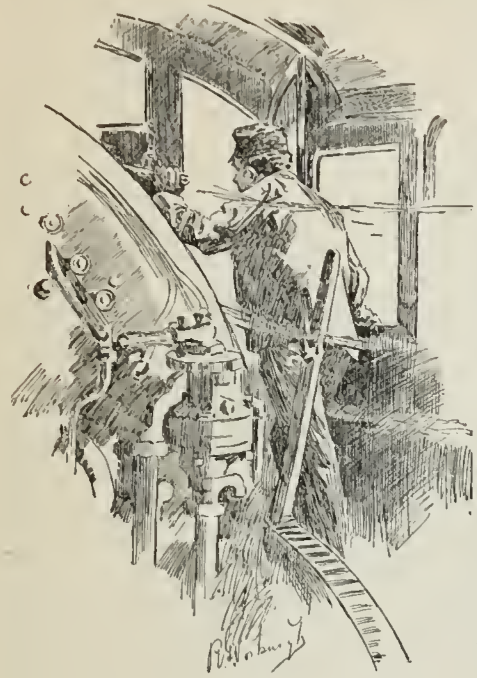
When the signal is given to start, the engine is panting under the suppressed power that has been generated in her boilers, but she gives at first a pull so gentle that the train rolls smoothly and noiselessly out of the station. The run is comparatively slow until the city limits are passed, and then the speed is gradually increased, but so imperceptibly that the passengers can hardly tell when they are traveling a mile a minute. The fast fliers have few stops to make, and the high rate of speed is maintained for long periods without interruption.

The eyes of the engineer are on the clock and time-table before him, and he keeps a sharp lookout ahead. For various reasons he may fall a few minutes behindhand at one point, but he manages to make up the loss at another. He has certain stops to make, and he makes all speed possible between them. But

THE FAST EXPRESS. A "FLIER" HAS THE RIGHT OF WAY.

he is not master of the road. At any moment a danger-signal along the line may confront him. He may be ordered to bring his train to a standstill at a small way-station, and there receive telegraphic orders to run on a siding. He asks no questions, but obeys orders. Five minutes

later a "special" may rush past him, and then the signals are set again, warning the engineer of the express that he must make up for lost time.



THE ENGINEER ON THE LOOKOUT.

To understand this delay, and the sudden changes made in the time-table, it will be necessary to go back to headquarters and to watch the general superintendent and the train-despatcher. Although many trains running on the line are hundreds of miles away, the exact position of every one, every second in the hour, is known and recorded. A telegraph-operator is working industriously in the office of the train-despatcher, receiving and sending orders. The running orders of all the trains are directed from this office. Each engineer has orders to make a certain run according to the time-table, unless other orders from headquarters interfere.

If an accident happens on the road, the train-despatcher knows it almost as soon as the passengers. A breakdown of some local train on the main line may upset all the calculations of the day. Immediately the expresses running on that line must be stopped before a collision occurs. A snow-storm may blockade a train on the northern branch of the road, and thereby make necessary a change in the regular schedule.

A train from the West is half an hour behind, perhaps, and this interferes with the regular running of the other trains. Arrangements must be made to let trains pass without accident. The express-trains nearly always have the right of way. A Western express may be behind time, and start out five minutes ahead of some special express. In this instance she must give the special right of way, and she is forced upon some siding. The special express passes without losing a minute.

There are fifty trains coming and going, one behind time, another ahead, probably, and each crowding out another. The train-despatcher has to regulate this tangle and keep things running smoothly. Thus it is that the engineer of a flier may suddenly find himself side-tracked.

Should the train-despatcher make a mistake, or fail to make arrangements for two fast-moving trains, the block-signal system would probably prevent an accident. The block-towers are connected by telegraph-lines, and a bell-code enables the men to communicate directly with each other. They can stop a train at any moment by means of their signals, independently of orders from headquarters. Thus the engineer depends entirely upon others to keep the track clear, and he merely runs his train as near schedule time as possible, and keeps his iron steed in perfect condition.

It is owing to these many safeguards (besides which, of course, the strength of the rails and firmness of the road-bed must be considered) that rapid traveling is made as safe, if not safer, than slow traveling, especially on the best-equipped roads, where every modern device for avoiding accidents is employed.

A WORD ABOUT WIRELESS TELEGRAPHY

BY JOHN M. ELLICOTT, LIEUTENANT U. S. N.

Some years ago, after a few days' leave, a naval officer went to a certain city, early one morning, to rejoin his ship, and found that she had sailed away. Not knowing where she was bound, he felt very much "at sea," when a friend asked him why he did not telegraph.

Said the friend: "Your ship has been fitted with the wireless telegraph apparatus, and there is a wireless station here."

"Can you call up the *Prairie?*" asked the officer, at the wireless station.

"Oh, yes," was the reply, and the operator tapped off a few loud and luminous sparks on his transmitter. Almost immediately the little wheel at his elbow commenced reeling off its tape with dots and dashes on it.

"Ask the *Prairie* where she is," said the officer, "and inform her captain that I am here waiting to report on board."

The message was quickly sparked on its way, and within three minutes the tape reeled off, in reply:

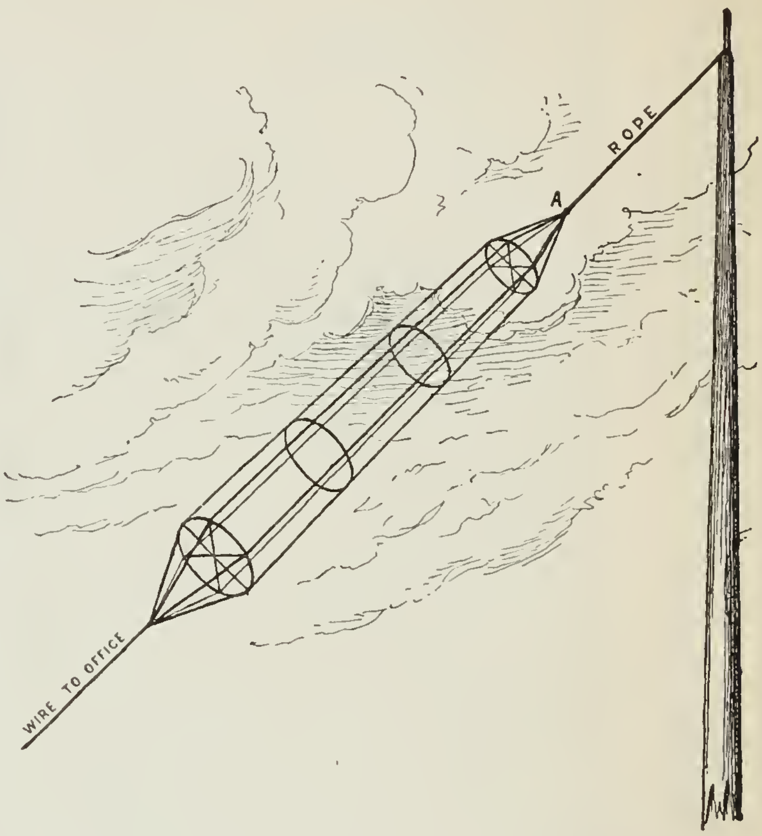
"The *Prairie* is one hundred and twelve miles at sea, but will return this afternoon."

"All right," said the much-relieved officer. "Telegraph her steward to save my lunch."

From the beginning of 1903 experiments with wireless telegraphy between ships at sea and between themselves and the shore were made in the navy. Several systems were tried, under the supervision of a board of naval officers, before one was finally adopted. Stations have been established at various places on shore, and vessels properly equipped for use of the "wireless" in "war-games."

A wireless telegraph system on board ship consists of a dynamo to generate an electrical current; of a special telegraph apparatus to control that current, to break it up into long waves and short waves, and to send these waves through the air until they hit upon the receiving apparatus of another station and make dashes and dots on its receiver; and, finally, of wires from the telegraph apparatus to the masthead of the ship, so that the waves can start from there clear of all obstructions. These waves are spherical in shape and so extend in every direction. They might be compared to huge soap-bubbles that increase in size as they grow out from their source—the greater the distance, the thinner or weaker they become.

And here lies the trouble with wireless telegraphy: that the message goes in all directions. Not only the station for which it was intended will receive the message, but any other station which the message waves may reach before they lose their strength will also receive it. For use in war, that part of the trouble could be overcome by means of a cipher code; but even then an enemy's ship, receiving a message in an unknown cipher, would know that some vessel of the defending squadron was near. The worst part of the trouble caused by the waves going in all directions is that one set will get mixed up with other sets from other sending-stations, just as waves circling away from two or more stones dropped in the water will meet and get jumbled up. If two or more sending-stations try to talk at once, it will be, at the receiving-station, like trying to listen to several conversations at the same time. If one station is saying c-a-t and another d-o-g, the receiving-station may get c-d-a-o-t-g, or the waves may overlap so as to turn dots into dashes and make no letters at all. So, again, an enemy's vessel, approaching a coast and hearing on his "wireless" a defending scout trying to tell of his coming, can break in on the message merely by continuously repeating a single letter, and make the information completely unintelligible. It is said that this may be overcome by having the instruments, so to speak, "tuned up" differently from those of the enemy, so that the waves sent out would not fit his receiver, and *vice versa;* but even then the enemy could probably, by "tuning" his instrument up or down, strike the proper key and accomplish his interference.



SKETCH SHOWING HOW THE WIRE IS FASTENED TO THE MASTHEAD.

Sometimes other electrical connections in a ship get mixed up with the wireless telegraph. On a certain vessel in the navy, newly equipped with "wireless," there were electrical connections to her pilot-house to show the revolutions of the engine and also the speed registered by the taffrail-log. As soon as the vessel got under way a most garrulous conversation began over the "wireless" between the propeller and the taffrail-log. No doubt the propeller was quarreling with the log for not telling the truth about the speed.

The distance to which a wireless message can be sent is chiefly a question of the strength of the electrical current generated and sent out, and instruments are manufactured for different strengths according to the distance over which they are intended to be operated; but an instrument powerful enough to carry, say one hundred miles can be adjusted to a radius of only ten or fifteen miles, and to intermediate distances.

Here, again, an enemy might introduce serious interference, for it is said to be possible that an apparatus adjusted for short distances can be burned out or seriously deranged by receiving upon it the waves from another apparatus of much higher power.

A WIRELESS CALL.

Wireless telegraphy has not thus far been very successful overland. Mountains, hills, forests, and tall buildings seem to break up the waves and make them unintelligible. Coast stations are, therefore, established on prominent headlands, where there are no outlying islands to seaward.

These imperfections make wireless telegraphy at present chiefly useful in communicating with isolated places having no other telegraph; but we must remember that when the telegraph and telephone first came into use they were in many ways even more imperfect, and their development into the systems of to-day was never even dreamed of.

A JUMBLED WIRELESS MESSAGE.

It is plain to see that the need which nothing but wireless telegraphy can fill is that of communication with vessels at sea. Our government, with its usual enterprise, is alive to this. Wireless telegraphy undoubtedly came into the navy to stay, and has grown in usefulness and importance. Its commercial application over the seas is already vast. We have been accustomed to feel that when loved ones went out upon the great deep they passed, for the time being, beyond our knowledge and beyond reach of our sympathy, and became imprisoned in a realm of danger from which no cry for help or assurance of safety could reach us. Now, through this wonderful invention, we may learn their progress from day to day, even from hour to hour. They can tell us of their daily health; they can transact matters of daily business; they can assure us that they are speeding over sunny seas; or they can ask, when in distress, that a vessel be sent to their relief.

All this is practised now, not only on some of the naval vessels of various nations, but also on many of the great transoceanic passenger liners, and we cannot doubt that the remaining imperfections of wireless telegraphy will be, in time, completely overcome.

THE MARVELOUS TELEPHONE

When we speak a word we make the air move or vibrate; every different word makes the air vibrate in a different way. We call these vibrations air-waves. But an air-wave does not carry sound so far or so fast as electricity, so we use the telephone to change the air-waves into electric waves, which travel along the wire quicker than sound can travel from the tongue to the ear. When we speak into the telephone, a thin iron disk, acting on an electric current, changes the air-waves into electric waves, which travel along the wire to a disk at the other end. At this disk the electric waves become air-waves again, and give off exactly the same sounds as the sounds that first made the waves. These sounds are the words from our lips. Our words strike one disk and become electric waves; the waves strike another disk and become words again, because both disks vibrate in tune and exactly the same sound is given off by the second disk as is spoken to the first.

It is somewhat strange to think that a teacher of the deaf and dumb should be the one to make the transmission of the human voice possible over thousands of miles, and across continents and channels. Yet it was Professor Alexander Graham Bell, who was such a teacher, that invented the telephone, which, common as it is, for most of us is a great deal of a mystery. The telephone does not merely carry sound a long distance, but carries the human voice, and takes words and laughter over miles and miles.

Think how wonderful it is that a wire should speak words to you! If it made a mere fizzling or crackling noise in your ear, that would not be very wonderful. But this wire says words in

your ear which you can understand; words that have meaning; words that tell you important things. Even here the mystery does not stop. Most wonderful of all is it that the words which come to your ear on the telephone have the very tone of the voice that utters them miles and miles away. You can always tell on a telephone whether it is your father, your mother, your uncle, or your brother who is speaking. You recognize the voice.

How strange, how wonderful is this! Let us see if we can understand it.

If you put your hand before your mouth and speak against it, you will feel warm breath striking against it. If you place a stretched drumhead and talk against it you will feel the vibrations. Our voices, as we have said, set up movements in the air, and these movements are called waves because they move to and fro, somewhat like the surface of the sea, but much more rapidly. We hear people speak because these sound-waves enter our ears and beat against the ear-drums. In the telephone these sound-waves from our mouths are transformed into electric waves that can flow along the wire and then at the other end of the wire become transformed into sound-waves again and enter the ear of our friend in exactly the same manner as the telephone received these sound-waves from our lips.

The wonder is that the message is given off by the wire exactly as the wire received it from our lips. Men have been able to make a machine to do this because they have discovered waves of electricity similar to the waves made in the air by sound. Men can make these electric waves, so that the electric wire which carries our messages is really carrying electric waves, moving to and fro, or vibrating, just like the air-waves made by our voices. But electricity travels very, very rapidly, faster than the voice can travel, so that while the waves may move to and fro just as rapidly, yet the electric waves advance more rapidly and reach their destination earlier. Suppose that the human voice could be heard in Boston from Philadelphia, instead of only a few hundred feet at the most. Well, a message by telephone would get there much more quickly, because electric waves are much more rapid than air-waves. So you see that the telephone wire does not really carry the sound-waves. The wire does not carry such words as *love, business, health*. No; it carries electric waves. But the man at the other end of the telephone does not hear the fizzing, or the mere whisper, of these waves; he hears words; he hears *love, business,* and *health*—just as if his friend had spoken these words into his ear. How is it?

All that we can say is this: When we speak we make an iron disk vibrate like the stretched drumhead. This iron disk presses against some carbon granules in the nickel-plated case of the telephone transmitter behind the black rubber mouthpiece into which we talk. Through this carbon flows a current of electricity, and this current will be changed as the carbon is pressed and relieved by the rapid movement of the iron disk. Thus electric waves are produced in the live wire. There is an electromagnet at the end of the wire and a little disk of stretched iron which trembles as it is drawn to and from the magnet. Now this drawing to and fro depends upon the varying strength of the electric current due to the electric waves. The vibration of the iron disk produces a trembling of the air exactly like the trembling of the air caused by your voice, and so the iron disk produces the very words you spoke!

That is the explanation; but, if you think hard, you will see that it really does not explain the great mystery of the telephone. It does not tell us how the waves vibrating to and fro along the wire reproduce the exact sound of a voice in New York, with its little laughs and jerks, and make it come from a disk of iron in a room in Baltimore, as if the mouth of the speaker were in that very room.

A great telephone exchange, such as may be seen in a large city, is a wonderful sight. The walls are covered with what are called switchboards. Such boards, for example, enable a boy living in Hartford to talk to a boy in New Haven, and a girl in Boston to speak to a girl in Plymouth. They are very expensive and complicated affairs, and their destruction by fire is a great calamity. Once this happened in Paris, and it was necessary to cable to Chicago and have a switchboard that was constructed for another city sent to France immediately. It was shipped and erected within a few weeks by American workmen, because the factory in which it was made was the only factory that could do the work in a short time, and delay was almost unendurable. The switchboards of a large central station are filled with tiny holes like honeycomb, each bearing a number, and over them are dull glass knobs no bigger than a shoe-button, also having numbers. In front of these boards sit the operators, generally young women, who must have good hearing and be very quick, and should be free from nervousness.

At their ears the operators have receivers (the receiver is the part of the telephone that gives

off a message), and just under the operator's lips is a transmitter—the part of the telephone that sends a message. The receiver fits over the head, and the transmitter is placed directly in front of the operator, whose hands have to be quite free, as they are very busy.

When a man in his house or his office lifts the receiver of his telephone off its hook, one of the knobs of dull glass on the switchboard instantly lights up. Once we had the crank of a small magneto-generator to produce the current to ring a bell at the central office. But now in a city system the operator sees the light, looks at the number under it, and puts a plug into one of the holes in the honeycomb bearing the same number. The central operator then answers the caller, for as soon as the plug is put in, he is connected with the exchange. He tells the operator what number he wants. As quick as lightning she lifts another plug joined to the first one, and puts it into the hole bearing that number. When she does this a bell rings in the office or room to which the number belongs, the tenant takes up his telephone and speaks directly with the person who has called him up. When they have finished talking, and put down their telephones, the little light goes out, and the operator removes the plugs. They are then "cut off."

This is the business of a telephone central office. It is wonderful to see how quietly everything is done. There is no noise, no excitement, but the nimble fingers of the young women are moving quickly under the watchful eye of the chief operator. Although the little "glow-worms" are bobbing in and out on the switchboard all day long, it is so still that you could almost hear a pin drop on the floor.

The chain of operations in telephoning, as most of us now use the telephone, is not so simple as once it was. We daily talk to many more persons than are on the switchboard of one exchange; in fact, in any large city we are connected every day with many exchanges. The operator repeats our call to the next exchange, and the electricity travels along the trunk wires as they are joined to connect the two persons desiring to converse. But we go much further. We do not confine ourselves to a single town or city. We can telephone about all our immediate neighborhood and its suburbs; in fact, almost across the continent; and conversations from New York to Denver have been possible for some years.

Here again the quick-witted operator helps us. A man in Boston wishes to talk with a business friend in Chicago. He does not know his telephone number, only the address of his street or office. He calls up the long-distance operator, who has on her desk telephone directories of all the great cities and the country lines, and gives his friend's name. Soon his bell rings, and the long-distance operator reports that his friend has been called to the telephone in Chicago, and that the line is clear for conversation. Indeed, some large business houses have such lines for a certain time each day; or, they may have a private wire, but this is very expensive, as there must be two wires to form a metallic circuit, and these wires must be of pure copper and heavy, so that the electric current will flow readily.

Now, if there is a sleet-storm, the wires may become loaded with ice and break under the strain. But this will not interfere with the wires underground in our large cities, or those that are placed in conduits underground alongside of railway tracks or the highway. Instead of two wires, we can use many pairs of wires insulated from each other by paper or rubber, and form them into a cable which may be drawn through a pipe or through the hole in a conduit. But the electric waves do not flow so readily along the wires in a cable, so we have to employ devices to make their passage easier; and when we have a long underground line we insert at regular distances small coils of wire which have the effect of strengthening the current. This is the reason why we cannot talk across the Atlantic ocean, for the electric waves corresponding to the voice are very different in their rapidity and nature from those sent along by the telegraph operator in the cable-office. But the loading coils have been used with submarine cables up to 100 miles or so with success, and some day we may have a cable through which electric impulse will pass with sufficient strength to be reproduced at the other end in the form of sound.

So necessary is our telephone that every one who can must have an instrument in his house or office, and usually on his desk. So many telephones are in use in the United States that there is an instrument to every fifteen persons. Even the farmer must have his telephone, and if there is not a company in his neighborhood, he will unite with his neighbors to maintain coöperative lines. Sometimes he even uses his wire fences for conductors in place of the wires on the familiar poles.

Yes, the telephone makes everybody neighbors, and saves much time that often is valuable, as in case of illness or fire. In England the telephone is a part of the post-office, but in the United States it is maintained by private companies, and sometimes there are two in the same city.

THE EIGER. THE MÖNCH.

THE JUNGFRAU TUNNEL

BY F. W. WENDT

"Yes, pretty rough trip," Uncle Tom called back, leaning over the railing of the steamer that had brought him home again. And in truth it must have been; for when May and Harry, standing on the pier, looked up at the huge black funnels, they saw large white salt-patches clinging to the very top, showing that the ocean had climbed away up there.

On the evening of Uncle Tom's arrival, a merry little family party had gathered around the Marston tea-table. The red-shaded lamp in the middle of the table, among steaming biscuits and delicacies of every kind, threw a fine, cheery glow over everything. Even the singing tea-kettle bubbled and chuckled, and danced its little cover up and down in high glee, because Uncle Tom had come home again from Europe. When he came from abroad he always had news and stories to tell, which May and Harry enjoyed as much as their parents, Dr. and Mrs. Marston.

"Well, Tom, how fares the world on the other side of the Atlantic, and what news can you tell us?" asked Dr. Marston.

"The most interesting novelty I have found is a plan to take a railroad excursion through a tunnel to the very tip-top of Europe amid snow and ice," answered Uncle Tom.

"Whew—w—w!" said Mrs. Marston with a little shiver; "how cold and wet and tiring that must be."

"Not if you go in the grand way proposed by the Swiss engineer, Herr Guyer-Zeller. You get into a comfortable car in the valley, and without the least exertion on your part you slide up, up, up to one of the highest and most beautiful snow-peaks of Switzerland, the Jungfrau Moun-

THE JUNGFRAU.

tain. Around you and below you lies a magical panorama of ice and snow, while in the distance you may see the landmarks of three great nations: Monte Rosa of Italy, Mont Blanc of France, and the Black Forest of Germany."

"Why, you talk just like a guide-book, Uncle Tom!" said May.

"Then I am making a mistake, because guide-books are seldom interesting. First class in geography, stand up. Now, Miss May, I am going to start in by asking questions. Do you remember when we were all at Interlaken two years ago?"

"Oh, yes!" said May; "and the big white mountain, that looked like a piece of sugar, right in the front of the hotel."

"Yes, I see you remember. Only that big mountain, the Jungfrau, is miles away from the hotel, and even at that distance it looks very, very high. It is more than 13,000 feet."

And then Uncle Tom explained to them all how Swiss engineers had thought it would be a great thing to give any one who cared to go a chance to reach a place where snow and ice never melt all the year round, and to look down from that tremendous height and see what a beautiful world this is.

"Now bring your map of Switzerland, May, and I will show you just where all this is to happen."

"And I am going to help clear away the tea-things. Then we can make believe that the table is Switzerland," said Mrs. Marston, "and Uncle Tom can take us with him and point out places on our make-believe Switzerland."

Uncle Tom went out, and when he came back with a large package of photographs under his arm, he found everything ready for the "trip." The rough, dark-green table-cloth was a fine ground to build upon. Large and small plates were to represent cities, and cups of different sizes were ready to be put into the proper places as snow-covered mountains.

"Ah! here we are," cried Uncle Tom. "Now, ladies and gentlemen, we will take you up higher than you have ever been in your life. All aboard!—we start from Interlaken.

"On the map, you see, Switzerland looks like a large, irregular ink-blot, squeezed in between France, Germany, and Italy. Its boundary-line

ALPINE CLIMBERS.

is very ragged, little tails and legs and fringes sticking out all around. But our green, oblong table will do well enough." Uncle Tom took up two large plates. "Now find Berne and Lucerne on the map, and put the plates on the correct places on the table."

Harry and May, after a little study of the map, laid them in their proper positions. Then they found Interlaken, and marked that site with a small saucer. The three formed a triangle in the middle of Switzerland, with one of the corners, marked by the Interlaken saucer, pointing south.

"That is to show us exactly where we are," said Uncle Tom. "Now below Interlaken we will place three 'tea-cup mountains.' The one on the right is the Eiger, the next one, to the left, touching it, is the Mönch, and the largest one, to the left of the Mönch, is the Jungfrau.

"A train leaves Interlaken early in the morning and takes us through the beautiful Lauterbrunnen valley. Then we have to change cars and get into a funny little combination composed of one car and a small locomotive. This strange train pushes and puffs up the steep incline with us, and gives us a fine view of the mountains—the Eiger, Mönch, and Jungfrau—the mountains which are to be pierced by the great tunnel through which the ascent is to be made.

"Every minute the scenery changes. The river below and the chalets grow smaller and smaller, and finally, as we look down, appear like Noah's-ark villages.

"We have reached Scheidegg, the last station at present, and the beginning of the great railway that is to be built. We are very high, about 6300 feet, but as yet we seem to be only at the foot of the three mighty mountains that you can see in this large picture. The one farthest to the left is the Eiger, where the tunnel is to begin. Then comes the Mönch, and the largest one on the right is the Jungfrau. Here also is the plan that shows you exactly what the engineers are going to do."

Uncle Tom placed a tracing beside the photograph. "Do you see that dotted line?" he asked. "That is how the tunnel is going to be built. Where it begins on the left is the farthest point you can now reach by rail—Station Scheidegg, as I have told you.

"One day I walked up toward the point where the engineers propose to begin the tunneling. Pickaxes and powder and dynamite will slowly march ahead of them and open the passage for present and future generations. First into the very heart of the Eiger mountain; then, after a sharp right-turn, through the next mountain, the Mönch; still on, under the glaciers and ice and snow fields, to the center of the Jungfrau, to within about 200 feet of the top, directly under the highest peak. A large circular shaft will be run vertically from here to the summit. There will be steps going up this shaft, but as two hundred feet is a pretty long climb by means of a stairway, a large elevator will shoot up and down, and whirl people from the dark interior of a mountain into the dazzling sunlight of the most heavenly Swiss panorama."

"Why, that is like 'Arabian Nights' and 'Aladdin'!" exclaimed May.

"You are quite right, May; people do things now that seem more incredible than the feats

accomplished by the slave of Aladdin's Wonderful Lamp," said Uncle Tom.

Harry had been thinking and wondering. He was a bright lad, and always wanted to know the why and wherefore of things.

"How long is that whole tunnel going to be?" he finally asked.

"Over six miles."

"And the train goes uphill under ground all the time, does n't it; and has to go very slowly?"

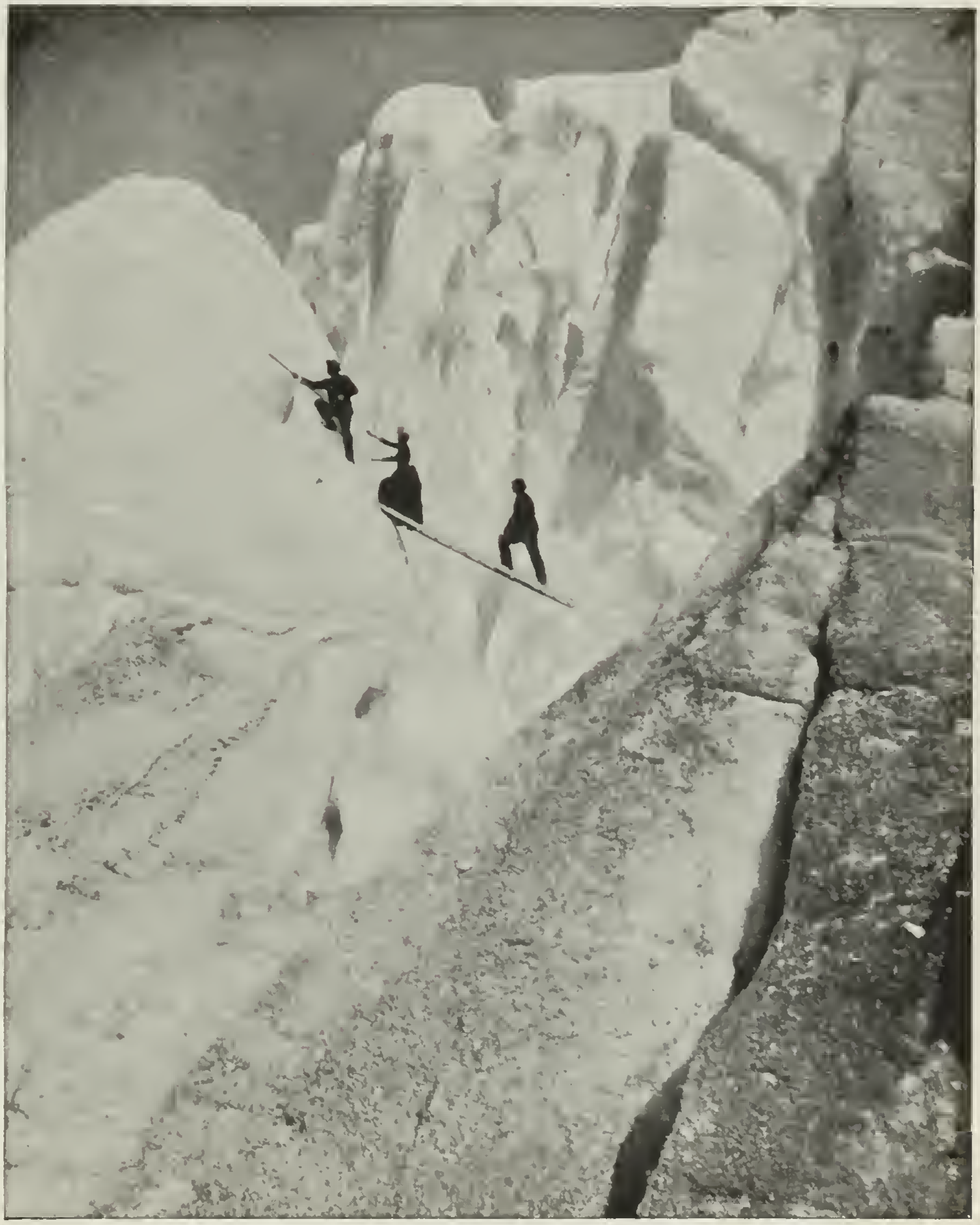
"Yes."

"Then," said Harry, "I don't think I would like to creep around in darkness, inside of a mountain, like that, and not see a thing."

"You are right, my boy; but it will not be necessary. Every fifteen minutes there will be a large, roomy station, with great windows cut into the mountainside, from which there will be a view of fairyland even before you get to the tip-top. And nobody will be asked to go on to the end unless he likes.

"Now, I am going to show you how people used to, and still do, climb to the top of the Jungfrau." Uncle Tom drew out other pictures—pictures of snow and ice with a few persons climbing up across the crevasses. "One wrong step," said Uncle Tom, "and they go shooting down thousands of feet. But not only that: the exposure and the cold are terrible, and many people have, as a result, lost their lives. It takes several days to make the perilous ascent and descent, and only experienced and hardy mountain-climbers, with the aid of skilled guides, dare attempt it.

"And now see how all changes when the railroad is built: One takes a comfortable seat in a car driven by electricity, and in a short time is carried to view a panorama that few, until then, have ever seen or dreamed of."



HOW THE MOUNTAINS ARE CLIMBED TO-DAY. CROSSING A CREVASSE.

Uncle Tom paused. Dr. Marston was blowing large rings of smoke from his cigar.

"Well, Tom," he said, "that is all very beautiful, but it is not practicable."

"Why not?"

"Because, in the first place, anybody who suddenly rises to that altitude, more than 13,000 feet, would become very ill through the change in the air-pressure."

"Yes, most people would become ill if they *climbed* up, but not if they were *carried* up. It is not only the rarefied air that affects them, but the exertion of the climb uses up the oxygen in the blood, and that of course makes people more susceptible and ill."

"How can you prove that?" asked Dr. Mars-

ton. "No one has ever been taken up there yet without climbing."

"No," said Uncle Tom; "we can only reason it out; a very ingenious experiment has been made with guinea-pigs."

"With guinea-pigs!" called out little May. "Is n't that funny?"

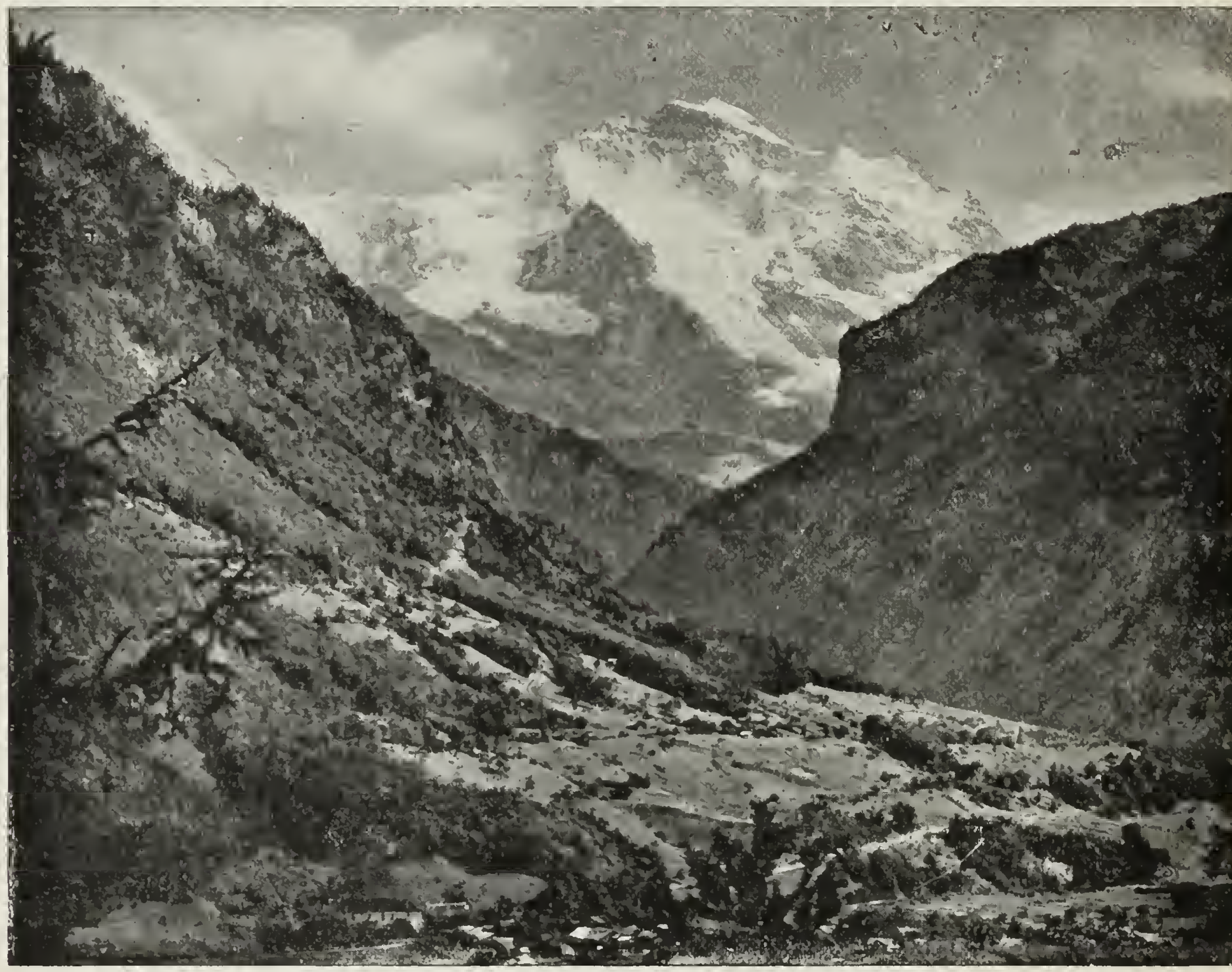
Then Uncle Tom told the children how scientific men had proved by means of animals that the sickness that overcomes most people at great heights is due as much to exertion as to the altitude. Guinea-pigs were chosen to experiment upon; and as it would have been difficult actually to take them up the Jungfrau Mountain, a very clever scheme was found to produce the same conditions.

"Air, light as it may seem, weighs fifteen pounds a square inch at the level of the sea. The higher we rise the lighter or more rarefied it becomes. This we must fully comprehend to understand the experiment. To begin with, we shall need a large glass bell-jar, one from which the air can be pumped. We can tell exactly how light the air under the jar is at any moment by the instrument connected with it." So saying, Uncle Tom showed a picture of the apparatus.

"It looks like a thermometer," said May.

"It does; and it is a similar instrument, called a 'manometer,' or measurer of the pressure of gases, such as air. Under the jar there is a wheel, like the wheels that we have seen squirrels play in. By means of electricity they can make this wheel revolve slowly or quickly.

"And now our experiment begins. We put two guinea-pigs, called 'John' and 'Jim,' under the glass jar. John, however, is placed in the wheel, while Jim is allowed to lie down quietly wherever he pleases under the jar. We then start the wheel going in the direction of the hands of a clock, and so if John does not move his legs and walk forward, the wheel by its motion carries him backward and up. So poor guinea-pig John has to trot forward as fast as the wheel-floor under him moves backward. We know exactly the size of the circumference, and by a sort of cyclometer we can tell how far we



THE JUNGFRAU, FROM THE RUGEN, NEAR INTERLAKEN.

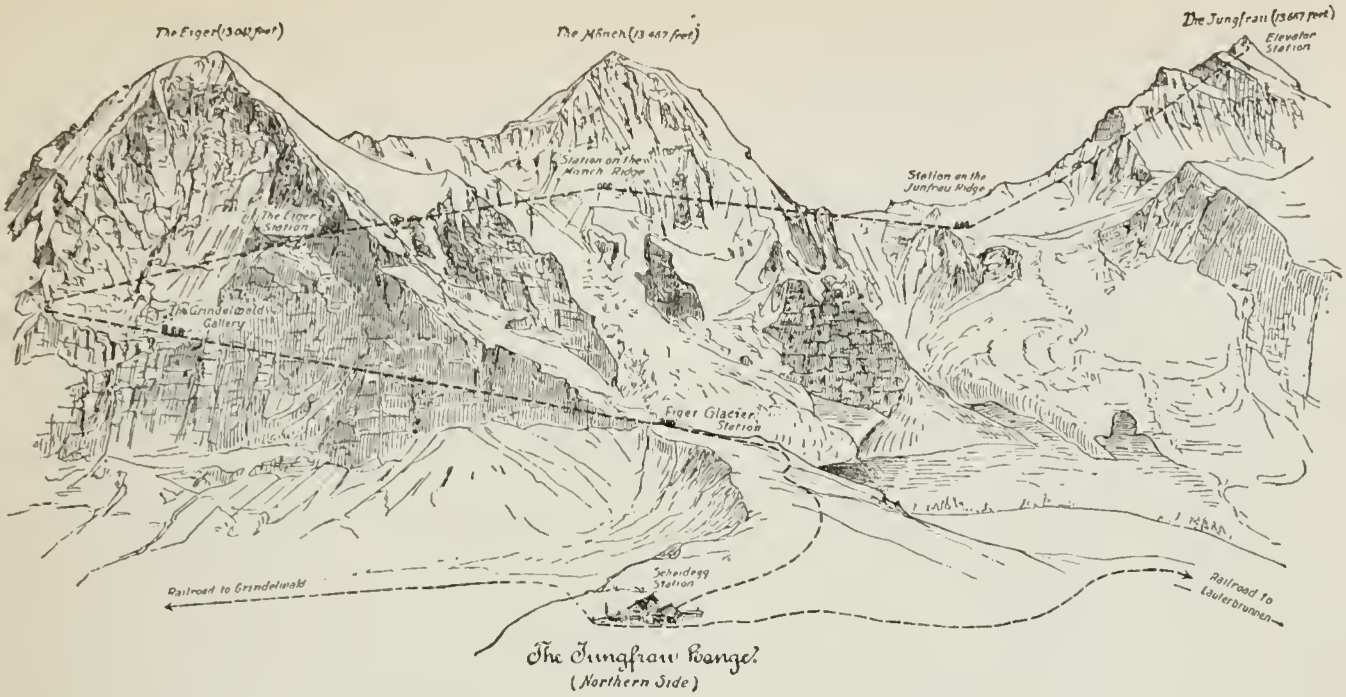


DIAGRAM OF THE JUNGFRAU RAILROAD.

have made John run in the wheel. By slowly pumping out air at the same time, we produce the same conditions as if John were running up a mountain—up the Jungfrau. As soon as the air becomes as light as it would be on a mountain 12,000 feet high, poor John begins to show signs of weariness, and when we keep on and make him go higher still, to 14,000 feet altitude, he falls on his back and is no longer able to move. Jim, on the contrary, in the same light atmosphere, is quite well, as he has made no exertion. If, however, we go on rarefying the air until it is as if at the altitude of the Himalaya mountains, 24,000 feet, Jim too succumbs.

"This little experiment proves that a living being *carried* up to a reasonable height will suffer little discomfort, while the one who *climbed* to that altitude will in most cases become ill. If a human John climbs up the Jungfrau around the outside through snow and ice, and a human Jim rides up comfortably through the great proposed tunnel, Jim will very probably have a good time and enjoy the view when he gets to the top, while poor John will feel exhausted and ill—'mountain-sick,' as it is called."

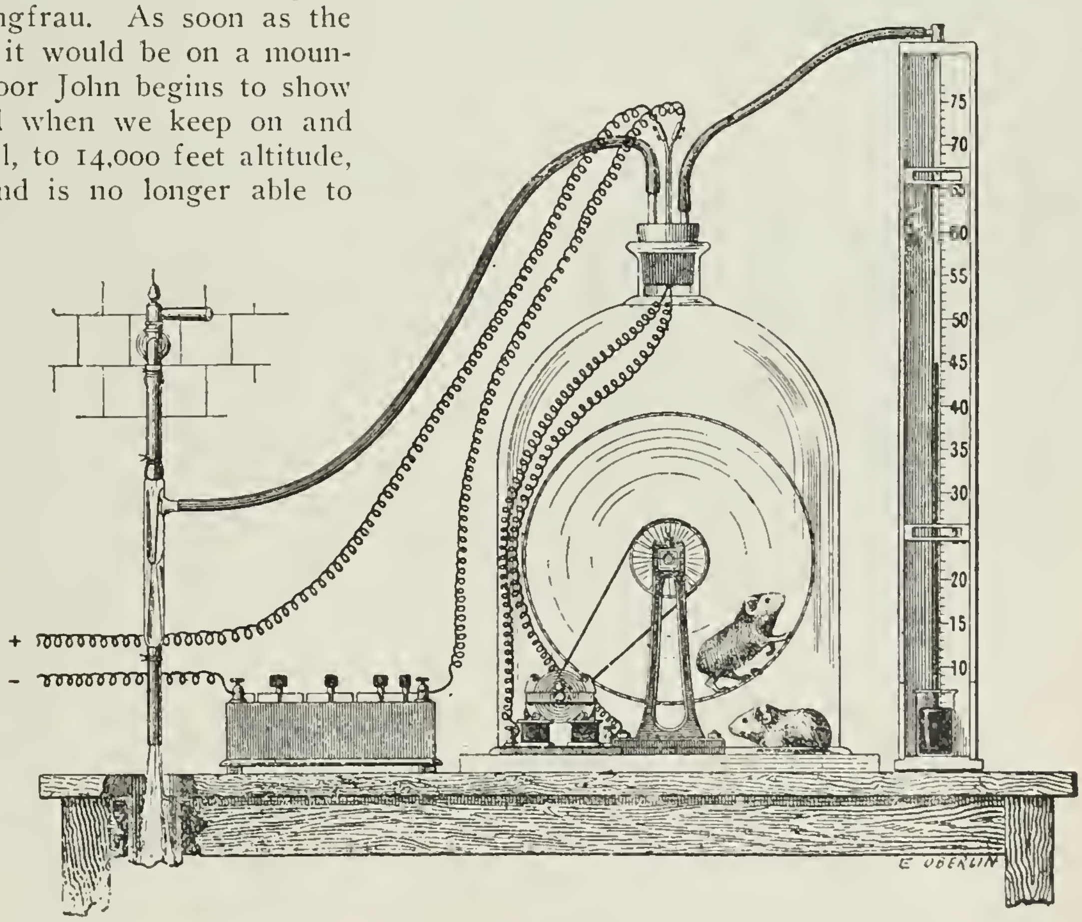


DIAGRAM OF THE EXPERIMENT WITH THE GUINEA-PIGS.

"It seems to me," said Mrs. Marston, "that your tunnel and railroad will do much to drive the poetry out of the Swiss mountains."

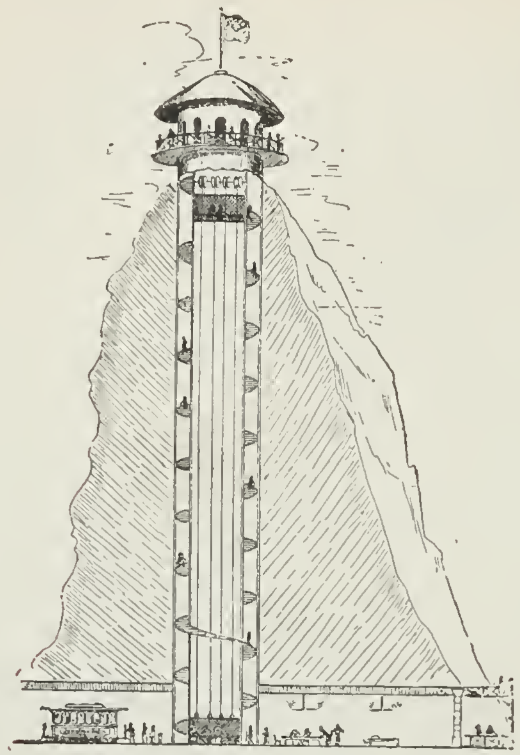


DIAGRAM OF THE SPIRAL STAIRCASE AND ELEVATORS TO THE SUMMIT OF THE JUNGFRAU.

"Perhaps, for the very few who are able to climb up by means of the alpenstock, that is true," agreed Uncle Tom; "but it will create poetry and show the sublime in nature to thousands of men and women and children who cannot and dare not go there now."

The cheerful fire in one corner of the room had gone on crackling all the evening, unmindful of the fact that the family were away with Uncle Tom on their make-believe trip to Switzerland. May alone had gone to keep it company, and sat upon the polar-bear skin in front of the old-fashioned hearth, staring into the fire, where, she had declared, the logs looked exactly like the Jungfrau Mountain shown in the photograph.

Suddenly the great, tall clock in the corner of the room struck eleven. The familiar sound brought Uncle Tom and his party back from the top of the Jungfrau to the cozy dining-room—all but May. May's curly little head was resting upon the thick bearskin; she had traveled farther than any of them—for she had made the journey to Dreamland.

THE SIMPLON TUNNEL

The story of the boring of the famous tunnels through the Alps is like a fairy tale. There are three of these tunnels—the St. Gotthard, the Mont Cenis, and the Simplon—and through them, every day, hundreds of travelers pass out of Switzerland into Italy, beneath the Alps, in the very heart of the greatest mountains in Europe, with millions of tons of earth stretching for more than a mile between them and the sky.

Let us take one of these tunnels only—the Simplon. The work occupied 10,000 men nearly eight years, and cost over $15,000,000. And so the dream of ages was realized—to get quickly, at this point, from one side of the Alps to the other. When Hannibal crossed the Alps with his marvelous army, it took him fifteen days, and cost an enormous number of lives. Napoleon took five days to cross when he set out to conquer Italy. He did not forget the dangers and difficulties of the crossing, but when he became emperor he built the Simplon Road—an extraordinary road running along the Simplon Pass, over a shoulder of the mountain, and rising to a height of 6600 feet. It is 41 miles long; it is carried over 600 bridges, through many galleries and short tunnels cut in the rock, or built of solid masonry to protect the traveler from the swift rush of avalanches in winter. The work lasted six years, and cost more than $3,000,000. Until the opening of the Simplon Tunnel, the Simplon Road was the only way over the Alps at this point. The Alps are pierced by two other famous tunnels—the Mont Cenis and the St. Gotthard—but they are far away from the Simplon.

There are two features in which the Simplon Tunnel differs from all others. Being 12¼ miles in length, it is more than three miles longer than any other tunnel in the world. A more remarkable point is the immense distance beneath the surface at which it runs. When we reach the highest point to which the tunnel climbs in the heart of the mountain, we have still more than 1¼ miles of solid rock above us. Therefore, we may almost say that this vast tunnel runs *under* the Alps. It could have been made much nearer the top of the mountain, but that would have meant a very high climb for the trains before

reaching the tunnel. Therefore the tunnel has been made comparatively low down the mountainside. On the north or Swiss side the entrance is only 2249 feet above sea-level, and the entrance on the Italian side is only 2079 feet. The tunnel slowly rises till it reaches a height of 2310 feet. That is the highest point, and above that there lies a mass of mountain a mile and 575 feet high. The tunnel slopes slightly toward each end, so that any water which enters may run down the slopes and escape.

There never was such a story as that of the building of this tunnel. The engineers expected to find great heat—for the deeper we go in the earth the more the temperature rises. They expected to find a heat of about 100 degrees, but when they came to the worst part they met a heat of 132 degrees, while scalding water in enormous quantities flowed in upon them. There were rivers and lakes hidden in the mountains of which they had previously known nothing. There were soft parts too in the mountains, which they had not expected to find. For all ordinary work they were prepared.

The two ends of the tunnel—Brigue on the Italian side, and Iselle on the Swiss—became cities of industry. At each end a river was harnessed and made to supply power for driving the many kinds of machinery which were used. A new colony sprang into existence at each end of the tunnel, in which were comfortable homes for the workmen and their families, churches, hospitals and places of amusement.

And though these little towns were of wood, every place was lighted by electricity, made by the running of the harnessed rivers. No workmen ever performed their tasks with greater comfort while working deep in the earth. They had special clothes to work in, special provisions in the form of warm and cold shower-baths, and cooling chambers were furnished, to prevent their feeling the cold on coming out from the hot depths of the mountain into the chill atmosphere of the Alps. To guard against impure air, machinery was built which forced in enormous quantities of cold, pure air, and drew out the foul air. Few horses were allowed in the tunnel, because the vapors from their bodies made the air impure; and special watering machinery instantly converted the dust of the tunnel into mud, so that the men should not breathe it. The conditions for the men were really excellent, and the men deserved it, for they worked with extraordinary good will under conditions which might have been truly terrible.

Work was begun at both ends of the tunnel at once—with 6000 men on the Italian side, where the harder work was expected, and 4000 men on the Swiss side. Drills driven by hydraulic power were used to bore holes in the rock, and in the holes thus made charges of dynamite were placed and fired. Guns which were fired by water under heavy pressure smashed up the rock which the dynamite dislodged, and long trains carried away the rubbish and brought in building material, so that solid masonry could be built up to form walls, and to give extra support in place of the rock cut out. Day and night men were at work, working in shifts of eight hours each. All the machinery for the work had to be specially made, and with this the men bored away 18 feet of gallery a day; the men on the Italian side working toward the Swiss side, and those on the Swiss side boring in the direction of the Italian, so that when each side had done its work they might meet in the center of the tunnel.

For a time all went well. Soon, however, those on the Italian side met with unlooked-for difficulties. They broke into very soft and treacherous ground, where they had expected to meet solid rock. To make this secure, they erected enormous timbers, but these were crushed to atoms. Next, heavy steel girders were tried, but so great was the pressure of the moving masses above and all around that these became twisted like wires. Not until quick-drying concrete was built round them could the girders be made to hold up.

Then the workmen came upon an underground river of intensely cold water. It rushed into the galleries at the rate of 12,500 gallons a minute. That gives us 80,000 tons of water in the course of the day and night, enough to supply all the wants of a city of 900,000 people, or nearly Baltimore and Buffalo combined.

The poor men worked in mackintoshes and waterproof boots and leggings, but they were in a shower-bath the whole time, and up to their knees in water, and often in danger of drowning. Next, drainage systems had to be invented—pipes and deep channels in the rock—to carry away this dreadful river, and, after a delay of six months, the danger-spot was safely passed.

Very soon afterward, however, the rocks into which they were boring began to get hot and hotter, and streams of scalding water gushed out. Having passed a river of cold water, they had now come upon another, which filtered down through the scorching rocks, bringing their heat with it. It flowed into the galleries at the rate of nearly 250,000 gallons an hour—a river of scalding water. Again fresh machinery had to be thought out. Nobody on the spot dreamed of giving up the work, though everybody outside

thought that the task must be abandoned. The men on the Swiss side also had come upon baking rocks and scalding water. The same idea was adopted for both sides of the tunnel. On the Swiss side enormously powerful pumping machinery was put up, which pumped in cold water from beyond the end of the tunnel. This was pumped upon the burning rocks and upon the cracks from which the scalding water issued, and so cooled both rock and water. Cold water was also sprayed in the air to make it possible for the men to breathe.

The plan on the Swiss side worked well, until a great storm at that end of the tunnel caused a landslide, which cut off the water supply that had driven the pumping machinery. The hot water was still pouring in, so the engineers had to put up enormously strong iron doors, right across the tunnel where the boring machinery was placed. This, to a great extent, shut out the flow of hot water, and enabled the men to go on building up the walls in the rest of the tunnel. And there they had to leave their boring, and wait for the men on the Italian side to work their way through to them.

The brave fellows on the Italian side worked doggedly on. They now turned one river against another. The cold river through which they had fought their way was made to serve the pumps, and to help to cool the scorching rocks and water where their present work lay.

Little by little they worked their way onward to the spot where they expected to break through and find their friends on the Swiss side. They knew exactly the spot at which they *should* break through and make the tunnel complete. They had been for years working in what they hoped was a straight line. Had they gone quite straight, or had they gone astray? Might they have to go on boring, having found that they had missed the line after all? There was great excitement on both sides.

At last the men in the Swiss half heard the sound of the drills, and knew that their friends were approaching them. Twenty feet, nineteen feet, then only sixteen feet remained, and so the last barrier was gradually bitten away by the untiring drills. Then came the last charge of dynamite which was to open the way. It was put in and fired, and a hole in the rock eight feet wide opened. To the joy of everybody, they saw that the tunnel was complete! After twelve miles of boring, starting from different countries, the workmen met in the heart of the Alps with only the breadth of a hand between the points of their axes.

In May, 1906, the King of Italy and the President of Switzerland met in the tunnel, and a month later, nearly eight years from the beginning of the work, trains were running through the Simplon, the longest and deepest of all the tunnels in the world.

THE WONDERS OF THE TELEGRAPH

The communicating or transmission of language to a distance is of very remote origin. The word "telegraphy," strictly defined, means "writing afar off." As practised to-day, however, it has a broader meaning, signifying the sending of messages to a distance by any means excepting speech.

The method of transmitting messages by sight signals is perhaps one of the earliest known. The sending up of columns of smoke from the top of high hills and mountains was one method used by the Indians of this country for many years; and flag and torch signaling, or "wig-wagging," as it is called, is still used by the army and navy to a certain extent.

Signaling by sound, such as blowing a whistle and ringing of bells, is used generally throughout the world; while the electric telegraph, an invention of comparatively recent years, is the most important and most used of all. An interesting and instructive article could be written upon each of these different methods. But in the present article we shall confine ourselves to the electrical method.

Various methods of electric signaling were used to a limited extent up to the time of the wonderful invention of Samuel F. B. Morse and the practical working of his system which has resulted in our modern telegraph. A good deal of credit was due to Joseph Henry, a Princeton College professor, who, as the inventor of the electromagnet in a useful form, made the invention of Professor Morse possible and practical.

Nobody can say what electricity really is. It is not matter. It cannot be seen, though its effects are visible; it cannot be smelled or tasted. We call it a fluid because we cannot give it a better name. But though we do not know what it is, we know how to bring it into use, how to create or excite it, how to harness it, and make it our most marvelous and obedient servant; and one of the chief wonders electricity performs for

us takes place after we hand a telegram across the counter of a telegraph office. A telegram is one of the familiar things in our lives which are really so wonderful that no man can quite understand them.

To-day if we wish to send a telegram, say from New York to Charleston, we must have in the telegraph office a battery or dynamo from which we can send electricity along wires. If the wires coil round a piece of iron, then so long as the current of electricity is passing through the coil the iron acts as a magnet—an electromagnet, as it is called—and draws to it another piece of iron or a piece of steel. The moment the current ceases, the iron is no longer a magnet. When we send the electricity through this coil, we call it magnetizing the coil. The current flies swiftly along the wire, and while it is going the circuit is said to be closed. When the current ceases, the circuit is broken. Now, we will say, we are in New York, and we hand a telegram for Charleston to the telegraph operator.

Before him is a little lever of shining brass with a black rubber knob at the end. This lever is called a key. While that key is at rest, the circuit is broken. The moment the operator presses it down, the circuit is closed, and the current races along the telegraph wire. He taps away at his key, and the message flies over the wire, to be written down at the Charleston telegraph office. How is it done? Charleston is the receiving end. Well, there, at the end of the wire, they have an electromagnet made as we have seen, of wire and iron. A current comes from New York. It enters the office by the wire. It passes through the coil and makes the iron magnetic. The magnet attracts toward itself a little metal bar working on a lever, and every time this bar comes down toward the magnet the end of it taps upon a small screw; then when it goes up again it taps on another screw. Each tap that it makes corresponds with something that the operator in New York has done at his end of the wire.

The New York operator, as we have seen, presses down a key. That key, when at rest, has its knob raised in the air. There is a wire attached to the key. Now, when the key is pressed down, its under side touches another wire. The pressing down of the key joins these two wires together. That closes the circuit. The joining of the two wires instantly causes a current of electricity to flow from New York over the wire to Charleston. The instant that the key is allowed to rise from the wire underneath it, the current is stopped and the circuit is broken. While the current is flowing, the coil and iron at Charleston become a magnet, which draws toward itself the small metal bar.

Clever men thought out a way of making this of use. They arranged that certain signals made with the sending key should stand for certain letters, just as certain motions of a flag, or staff, or other signal visible at a distance meant some definite message arranged between the sender and the receiver. We have only to agree once for all that a certain sign shall stand for a certain thing, and then we know what it means. And that is how we got the telegraph's A, B, C. A very short pressure of the key in New York gives two taps at Charleston, one very quickly after the other, and a longer pressure gives two taps, but with a longer interval between them. These double tappings, one with a short interval between the taps, and the other with a longer pause, correspond with the dots and dashes of the Morse alphabet. This alphabet is now universal. There are a few differences between that used in America and that employed in Europe and in cable-working, but in the main one alphabet of dots and dashes serves the entire world.

These dots and dashes of the telegraph signals take their names from the first apparatus used by Professor Morse. He did not realize that the operator could read the signal and messages by ear, paying attention to the interval between the clicks. He accordingly arranged that his receiver, or the electromagnet at the distant station, should be able to record the signals visibly and permanently. This he did by attaching to the movable piece of soft iron that was attracted by the electromagnet a point or pen, so that when it was pulled down it would come in contact with a moving paper tape and pierce or mark it. If the soft iron, the armature, it is called, was held down but for a moment (a short signal), the mark was a point or prick, and was called a "dot"; when the key was closed for a longer time the mark was a "dash." But as telegraph instruments were developed, and operators became skilful, it was found that the sound was sufficient, and instead of the Morse register, after 1855 to 1860 various types of sounders were used to the virtual exclusion of recording instruments on most large systems in America.

Now we have spoken of sending a message from New York to Charleston as if this were a simple matter of a single circuit. This served to explain the principle, and in fact would be the case over a short line. If two school-boys in the same town connected their houses by telegraph, they would require only a simple circuit

of sounders, keys, batteries, and wires. But for a long distance it is necessary to have one or more relays where a sounder not only gives out the click for the ear, but sends its message along on the next stage. The relay is much more sensitive than the sounder, so it works a local circuit in which a loud sounder is placed with a battery of its own, and the feeble current in dots and dashes can be read by an operator in the usual way.

We have seen that when we send our telegram from New York to Charleston the telegraph operator turns the letters which we have written on the printed blank into telegraphic letters by tapping at his key the signals according to the Morse code or alphabet. Each tap is registered at Charleston instantly it is made. With each pressure upon the key the circuit is closed and the current passes for a certain length of time, conveying a sign that means part of a letter. Each time the key is placed at rest in its ordinary position, the current ceases to flow.

But there is a limit to the speed at which a man can tap his key. If he is very skilful and quick he may be able to send as many as forty words a minute. More likely he will not be able to send more than twenty-five. That is not quick enough when the message he sends, instead of being a little telegram from one of ourselves, is a despatch of thousands of words, as a speech or an account of some event for the newspaper. For this, another system is used. A message of 1200 words, for instance, would be divided, say among ten operators, each of whom sits before a machine that punches holes in a ribbon of paper, the holes corresponding to the letters of the Morse alphabet. Each clerk punches 120 words of the message at the rate of 25 words a minute, so that, when the work is divided in this way, the whole message is punched out on the tape, or ribbon, in about five minutes. The ribbon is then run through an elaborate telegraph instrument, called an automatic transmitter because it works itself. The ribbon runs through in such a manner that the circuit is closed at each hole in the paper representing a dot or a dash, and the current flows along the line, to be registered at the other end, in ink, upon a tape. By this machine, messages can be sent at the rate of 400 words a minute. The recording of the dots and dashes upon a tape at the receiving end is necessary, because no one could write out the message at the rapid rate at which it is received. The writing out is done from the printed dots and dashes on the receiving tape.

Perhaps the greatest wonder of the telegraph line is the fact that several messages can be sent at the same time. Thus we have duplex and quadruplex working. Two messages can be traveling over one wire at the same time from New York to Charleston, while two others are coming at the same time over the same wire from Charleston to New York. This is done by arranging different strengths of current. The messages that are traveling together from the north to the south are each sent by a current of different strength from that of the others, and the same is the case with those coming from the south. Each current goes to a receiver that takes a current of particular strength. If we have relatives away over the sea to whom we may wish to telegraph, we can reach them with a message carried by electricity under the sea. Cables, in which is used, not the bare galvanized iron wire we see on telegraph poles, but a copper conductor protected first by an insulation of gutta-percha or rubber, and then by a strong sheathing of steel wires, run under the Atlantic and Pacific oceans, under the Mediterranean Sea, the Black Sea, the Indian Ocean, the North Sea, the English Channel, and other bodies of water. There are about 250,000 miles of these submarine cables in use, so that we can exchange messages with Europe, Australia, New Zealand, India, China, and all civilized countries. The principle is the same as in the land telegraph, but the wires are different, and the rate of telegraphing is slower, as the current passing through these long wires is necessarily weaker, which makes the recording of the messages received a slower operation.

In fact, we do not have the loud clicking sounder nor the punctured tape. We have an instrument that can detect the feeblest currents, and this is a modification of the galvanometer, where a little magnet is suspended within a coil through which the current flows. If the current passes in one direction, the needle swings to the right; if it is going in the opposite direction, to the left. Once it was necessary to put a small mirror in the needle and watch the movement of a reflected spot of light. Now we have a siphon recorder where the needle carries a little pen filled with ink, which traces a wavy line on a paper tape. If there is an upward jog in the line, that means a dot; if it is down, it is a dash, and the message can be read just as easily as if it were picked out. The cable-key is different from that of the land telegraph, for, as we have seen, the operator not only breaks the current but changes its direction, so that the signals are more pronounced.

If the ordinary bare telegraph wires seen on the poles were used, the current would run off

into the sea and be lost; so the wires have to be encased in gutta-percha, and bound round with tape, and yarn, and brass, and tarred hemp, and over all are wound coils of stout wire, to protect the cable from the sea and from the rocks at the bottom of the ocean. For long distances, only one wire is placed inside the cable, but for shorter distances many can be used, as is done in a telephone cable. More than one message can be sent over the cable at the same time.

The speed at which cablegrams can travel is very great, though we have not yet the instruments to receive the messages quickly. A signal has been sent 8000 miles under water in a single second. So quickly does the flash travel that we can use a signal to determine exact time at distant places and compare the standard clocks of two astronomical observatories far separated. But we could not send a long message at this rate. It is costly to cable across the Atlantic, for not only is the cable itself expensive to make, lay, and maintain, but it can only do a certain amount of business in a year. On account of this expense codes are used by which one word may stand for a dozen or more words. By this means, time and money are saved. Once an English firm cabled from London to their manager in Victoria, British Columbia, and received the answer in a minute and a half, the distance traveled by message and reply together being 18,000 miles.

At an electrical exhibition in Chicago, a message was sent from a room there through the United States to Canada, from Canada to London, from London to Portugal, Spain, Egypt, India, and Japan. It came back by the same route, and was received in the same room from which it had started, but at another instrument. It had been round the world in fifty minutes. This speed of cable-signals has been strikingly illustrated on several occasions when the United States Naval Observatory at Washington on New Year's Eve or other special occasions has sent out a special series of midnight time-signals to mark the beginning of the new year. Telegraph and cable companies have united to send the tick of the standard clock at Washington, so that signals were received from points on the earth's surface as far distant as Greenwich in England and Adelaide in Australia, and from Sitka in far-away Alaska and Buenos Aires in South America. Messages east and west have met in Australia within a very few seconds, and the time of transmission to Sydney, New South Wales, was but 2¼ seconds.

It is apparent that our telegraph lines are not used much during the night hours except for newspaper messages and those of immediate importance. Accordingly, the telegraph companies determined to make a special rate for night letters in which many more words could be transmitted for the same expense as a day message which was sent over the line and delivered immediately. These night letters make it practicable for full instructions or particulars to be given by business houses to their various representatives, and for relatives and friends to send each other messages with complete information about their health, plans, movements, etc. These telegraph letters soon began to be extensively used, and they were followed by cable letters for which a similar reduction in rate was made for messages that would undergo a reasonable delay in transmission, but would reach across the ocean in sufficient season over a night or a Sunday to give the receiver the desired information in full and free from misunderstanding that might result from an abbreviated or code message.

Undoubtedly the most wonderful method of telegraphing is that without wires. It was known for some years that electric waves are carried through the air in all directions, with the speed of light, and this knowledge has been turned to useful purposes.

By the use of an instrument called a transmitter, these electric waves can be sent bounding forth through the air in all directions. By making a receiver in tune with the transmitter, capable of responding to the same kind of waves, we can make that receiver take a message. The first instrument devised to receive these electric waves was called a coherer. A coherer is a glass tube, sealed at both ends with metal, and filled with metal filings. When an electric wave comes along, it passes through this tube. It magnetizes the metal filings, and causes them to draw close together—to cohere, and to close the circuit. The wave is quickly gone, the filings are no longer magnetized, and the circuit is then broken again.

The coherer receives a light tap from a little automatic tapper, and the filings fall apart again instantly, to be as they were before, ready to receive the next electric wave. When the metal filings come together and close the circuit, they operate a bell or sounder, like the simple instrument in the country telegraph office, and the message that they tick is read and written down, ready to be sent to the person for whom it is intended.

But the coherer is only one of a number of devices that can be used to detect the electrical

waves. It must be remembered that these waves strike suspended wires that are raised above the earth's surface, sometimes singly, sometimes in pairs, and sometimes in the form of a net. These wires are called antennæ, like the long feelers on the beetle's head. They are familiar sights in the rigging of a modern battle-ship, or large passenger vessel, for now seagoing steamers that carry passengers are required to be equipped with wireless telephone for safety in case of collision or other accident. The waves striking these antennæ set up electrical oscillations in the circuit which will affect the coherer as has been described.

There are also other forms of detectors, many of which are very complicated and are arranged so that the various signals, even from across the ocean, may be received. These detectors, when rapid electrical currents are produced in the receiving circuit by the electrical waves, may have the magnetism of metals used in their construction affected; or a fine wire may be heated; or certain chemical actions may be set up; the conductivity of very thin gases may be altered; or certain crystals that conduct electricity may have this power of conduction varied under the influence of the rapid oscillations of the current; or, finally, there may be a movable conductor, near a fixed conductor in which the oscillations are taking place, so excited that it enables the presence of the waves to be detected.

Instead of the Morse relay and register used with the coherer, it is now customary to employ a sensitive telephone receiver, and the operator in his deck-house on a large battle-ship, or steamer, sits with this receiver at his ear, listening for the waves that come across the ocean, fall on his wires suspended in the air, and produce the oscillations in his receiver that make a loud click in the telephone. These signals are sent in the ordinary Morse code, and will be received on any ship where the apparatus is tuned to the same wave-length. Many stations, both on board ship and on land, can be tuned to the number of wave-lengths, and thus they are independent of any special system.

An interesting incident occurred in 1912 when a portion of the Royal family, of Great Britain, returning from India on a large passenger steamer, were shipwrecked on the coast of North Africa. Their signals of distress were heard on several ships which came to their rescue, but not by the British naval vessels at Gibraltar, whose apparatus was tuned to one wave-length only, as used in the British naval service.

Thus we send a message thousands of miles across the ocean without the help of wires. Here again the rate is slow. Cablegrams run off at the rate of fifty words a minute, but the wireless telegrams go at the rate of only twenty-five words a minute. Some day, of course, this pace will be greatly improved. Wireless telegraphy is one of the great gifts that inventors have given to mankind, and we cannot yet realize the importance of it to the world. How wonderful is the power that wireless telegraphy gives us to speak across the sea! In 1909 happened a wonderful thing, showing how the power of telegraphy without wires may save great disasters at sea. Let us read the story of how a man tapping away into space saved a thousand lives.

Let us picture to ourselves an immense steamship moving slowly from its berth. The pier is crowded with people waving their hands and fluttering handkerchiefs. From the side of the ship, on all the decks, lean a multitude of passengers waving farewell. The space between these two crowds slowly widens. Between ship and shore flows an increasing space of troubled water. The faces of people become indistinct. The sounds die away. Then the engines get to work in earnest and the great ship moves forward and draws impressively to sea. The passengers hurry to their cabins. They see that everything is comfortable for them. They put on overcoats and wraps, and take to the decks. Before they begin to walk about, however, they think of their families ashore, their wives, husbands, children, sweethearts. They go to one of the rooms on the ship and write messages of affection and good cheer. They ring a bell. A steward comes, and the messages are handed to him. They are carried to the operator in charge of the wireless telegraph. The passengers begin to walk about the liner and to enjoy themselves.

In his little deck-cabin the operator of the wireless telegraph sits before his machine. On the table in front of him are the messages of passengers, a pile of crowded papers. It is the business of the operator to send those messages. He flips an A, B, C into the ether, and somehow or another those letters are received on shore. They travel without wings, without wires; they arrive.

A fog descends upon the sea; the engines are slowed; the fog-horn begins to sound.

Tap, tap, says the operator, earning his daily bread.

Crash!

A noise like thunder. A shock that sends everything flying. A tearing and rending and splintering of timbers. A dull, thudding crumple of steel plates. The roar of water rushing in. The staggering shudder of the whole ship.

Shrieks and cries of people from every quarter. Voices shouting through the fog—loud voices of command. And darkness. Every electric light goes out.

The operator interrupts a sweetheart's message, and taps out the letters C, Q, D, the danger-signal of the seas. Through the cries of the passengers, above the shouts of command, piercing the black fog that shrouds the ocean, those invisible letters strike on receivers ashore, and on numerous receivers aboard other ships, almost at the moment when the operator sets them free. They mean to those who receive them: "In serious trouble, need immediate help."

"What has happened? The steamer "Florida" has rammed the great White Star liner "Republic." The water pours in, life-boats are made ready, the panic-stricken passengers pray for delivery from death.

Through it all the operator sits amid the ruin of his office, tapping, tapping, tapping his messages into space.

On another vessel, in another little office, another operator sits tapping away at the ether. The telegraph operator on the "Baltic" is sending his passengers' messages home when his receiver records the distress-call from the "Republic." The sinking ship is sixty miles away, drifting in a dense fog, and the "Baltic" changes its course and sets out to find it. From half-past seven in the morning till half-past six at night the "Baltic" scours the sea, talking all day long to the ship that is near sinking with a thousand lives. All day long on the sinking ship sits the telegraph operator, tapping into space a signal of distress.

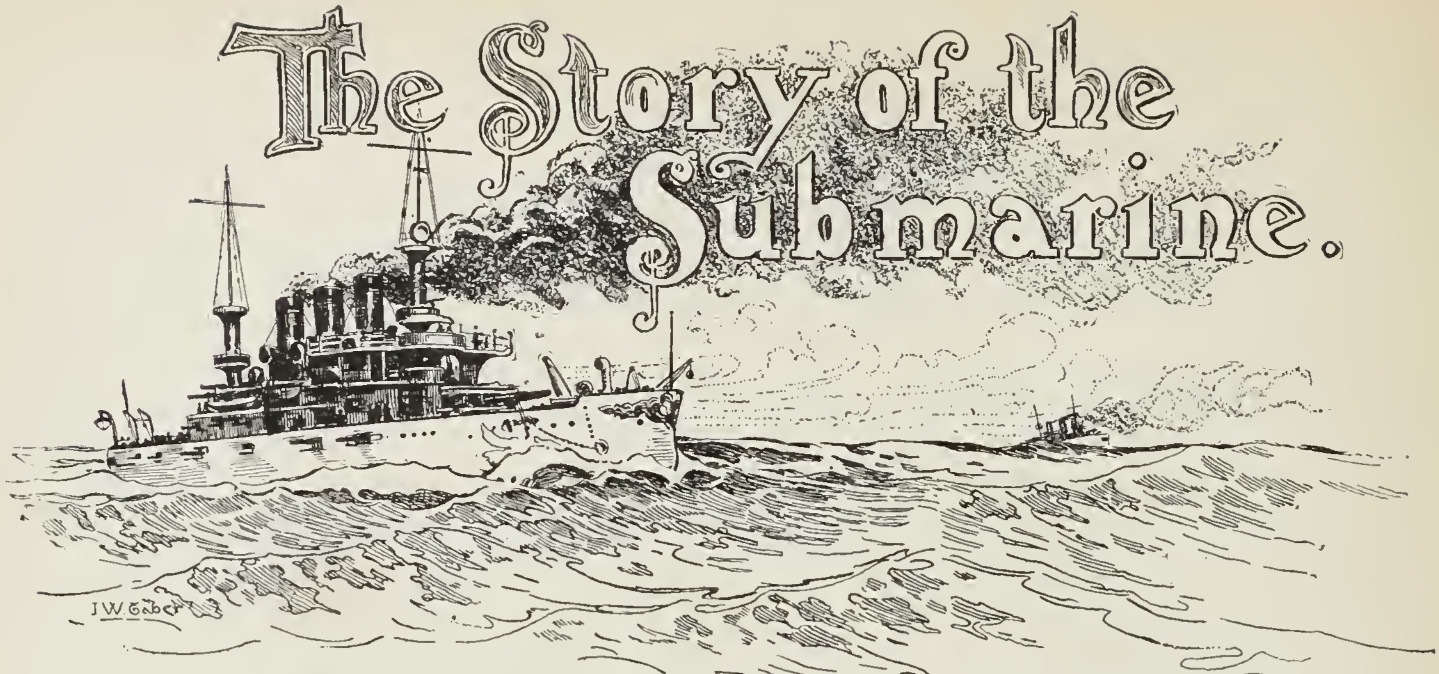
Let us try to imagine the scene. Two ships are in peril in a thick fog. Two thousand men, women, and children are in danger of death. In a little room on one of the vessels a man is tapping at a keyboard, tapping into space a bitter cry for help. The air-waves, set in motion by his tapping, travel sixty miles and then they find, on another ship, a sympathetic disk, on which they register themselves; and below in the operator's room on that other ship the tapping is repeated, and the ship's distress made known.

Two other ships pick up the silent cry that trembles through the fog, and all day long three vessels seek the sinking ship, with which they keep in touch by constant tapping and by communication with telegraph stations on land. It is a thrilling thing to think of—these ships drifting in the fog, talking to each other over sixty miles of space, carrying along an invisible ocean new life for two thousand beating hearts. "We are sinking rapidly," says one message. "We can hear a bomb to the west of us; is it yours?" says another. The "Lucania" asks the "Baltic" to "listen for four blasts." Another ship asks the "Baltic" to "make as much noise as possible." The captain of the "Republic" thinks he hears a steamer's whistle, and appeals to the "Baltic" to make haste, for his ship is "sinking fast."

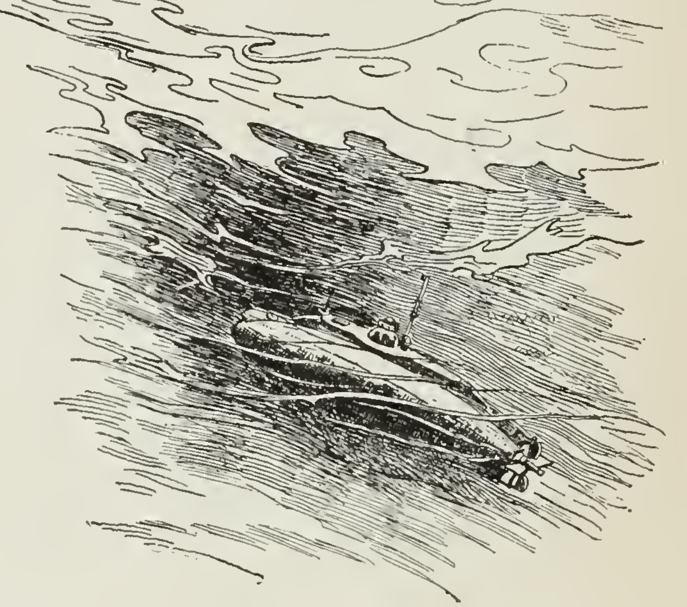
And then at last, after a whole day's search, steering and zigzagging for two hundred miles, the "Baltic" received the message from the sinking ship: "You are very close now; right abeam. Come carefully. You are on our port side. Have just seen your rocket. You are very close to us." They were within one hundred feet, and saw the faint glare of a green light, and in twelve hours the sinking ships were emptied of their living freight.

Only a few years ago the "Republic" would have been completely lost, and such a catastrophe was prevented, for the first time in the history of the world, by wireless telegraphy, a power that no man understands.

The Story of the Submarine.



BY WILLIAM O. STEVENS



There was a time when "Twenty Thousand Leagues under the Sea" was for me the finest story ever written; and when, some years afterward, I saw a picture of the Holland submarine, I was sure that the inventor had got the idea from Captain Nemo's "Nautilus." It is true that Mr. Lake, the inventor of the submarine that bears his name, was inspired to his life-work by reading Jules Verne's story at the age of ten; but the fact remains that the submarine idea was over two hundred years old when the clever French writer was born.

When President Roosevelt made a trip in a submarine at one time, there was a great stir in the newspapers; but not many people know that as long ago as 1620, King James the First made a journey of two or three hours below the surface of the Thames on board the first navigable submarine in history. This was the invention of a Dutch physician, Cornelius Van Drebel, a man in high favor with the king. It was built of wood, covered with greased leather to keep out the water, and propelled by twelve rowers, whose oar-holes, also, were protected against leaking by greased leather. Van Drebel boasted that he kept the air inside by means of a secret elixir, but after his death his enemies declared that he must have had air-pipes sticking out of the water. At any rate, he died with his secret while in the midst of his experiments.

When we think of the difference in mechanical science between then and now, perhaps the king who would risk his life in such a boat was not so much of a coward after all!

During the next one hundred and fifty years, several inventors tried to build submarines. One of them, oddly enough, was a John Holland, who took out a patent for his submarine in 1691. In 1891, just two hundred years later, another John Holland was perfecting a submarine which has come to be the accepted type in our Navy.

But the glory of making the first submarine that actually operated in time of war belongs to an American, David Bushnell, who built the "Turtle" to destroy the British blockading ships in New York Harbor.

When the "Turtle" was finished, she was manned by a sergeant of the Continental army who had been carefully trained in the use of the boat by Bushnell himself. One night the little submarine was towed near a huge man-o'-war, when it submerged and came up under the ship's bottom. But the sergeant found that, try as he might, he could not bore through the copper sheathing. Soon he found himself being carried away by the

tide, and, as day was breaking, he cast loose his mine and paddled for shore. The mine was set by clockwork and, after bobbing about on the surface awhile, it suddenly went off with a tremendous explosion, which did no damage. The attempt had failed, but it showed that submarine warfare was possible.

The chief objection seemed to be, and continued to be for nearly a century, that submarine warfare was "dastardly." The English were indignant at what they called "villainous and underhanded" methods, and Bushnell found that the American authorities felt the same way; so all he got for his trouble was hard names from friend and foe.

The next submarine builder of note was also an American—and a famous one—Robert Fulton. His boat was the "Nautilus" (from which Jules Verne took the name for Captain Nemo's ship), propelled, like the "Turtle," by hand, only instead of oars there was a wheel astern. She had also a sail for use when on the surface. Notice the first appearance of the "cigar shape," which set the fashion for all the submarines that have followed.

As Fulton was in France at the time he was building the boat, he tried to get the French government interested. Finally, in 1801, he was allowed to give his boat a public trial in the harbor

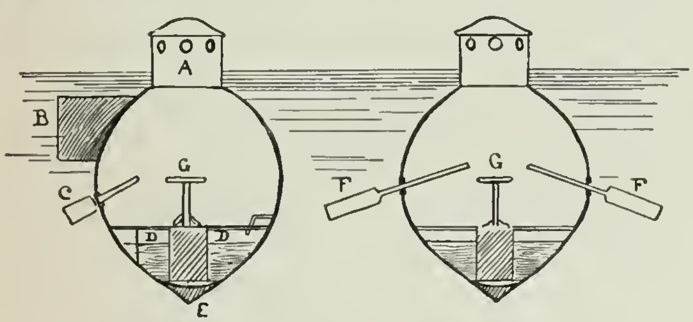


DIAGRAM OF THE SUBMARINE "TURTLE."

of Brest. There he made three trips without a hitch; in the last one he stayed under water five hours at a stretch, and blew up an old hulk with his mine. The crowds cheered, and the officials smiled; then, after pondering awhile, they told him politely that the "Nautilus" would n't do. It was much too novel for old frigate captains to encourage.

Disheartened by this, Fulton went to England, where he gave another successful performance in the Thames by blowing up an old Danish frigate. Again, his very success was against him. The Admiralty solemnly declared that the "Nautilus" was a device that threatened navies; and, since England's mainstay was her navy, she must not encourage such a thing! Poor Fulton came back to America, and even here he met nothing but opposition to his "villainous" idea. In despair, he gave himself up to the development of the steamboat.

Another American, with a more romantic turn of mind, began in 1821 to build an enormous sub-

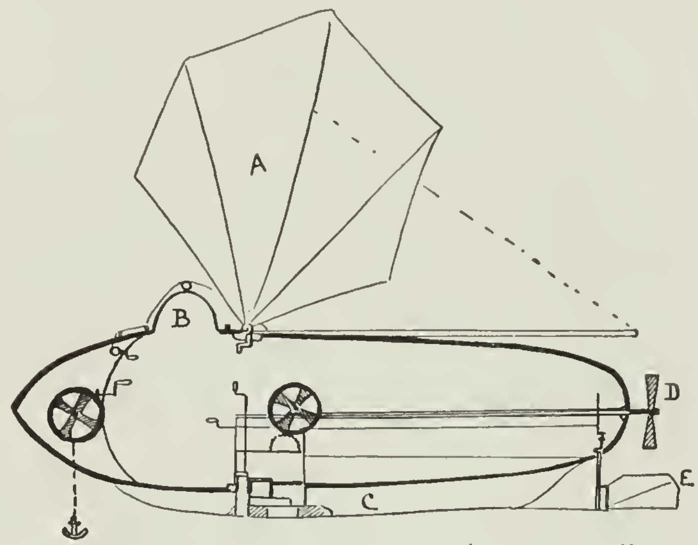


DIAGRAM OF THE SUBMARINE "NAUTILUS."

marine, with which he was going to St. Helena to rescue Napoleon! Unfortunately, Napoleon died before the boat was finished. But throughout the first half of the century, men of all nations, especially the French, were puzzling over submarine construction. Bauer, a German, had an experience even more discouraging than Fulton's. Failing, after endless trouble, in Germany, Austria, and England, he succeeded only long enough in Russia to prove that he could make his boat work under water, when there, too, he was driven by official greed and jealousy out of the country.

After Fulton's demonstrations, the greatest advance in submarine construction was made by the Confederates in our Civil War. They combined the uses of steam and electricity, and carried the "spar" torpedo in the bow. But the only one of their submarines that succeeded in destroying an enemy was as simple as the "Nautilus." This "David," as submarines were then called, was about sixty feet long and manned by nine men, eight of whom worked the screw-shaft by hand, while the ninth acted as pilot. On the night of February 17, 1864, this little craft went out to attack the "Housatonic," a Federal ship anchored in Charleston Harbor. The officer of the deck saw something rippling along the surface of the water directly toward the ship, and instantly gave the alarm; but, before the "Housatonic" could move out of the way, the "David" was alongside, and, a minute after, one hundred pounds of powder exploded under the keel of the ship. She fairly jumped out of the water and then lurched heavily to the bottom. During the

confusion of rescuing the survivors, the "David" apparently escaped, for she could not be found.

This exploit was the first case of a submarine destroying an enemy, and the only case in the Civil War. The boat, before this, had had a tragic history. Five times before she had gone to the bottom with her crews, and five times she had been raised and remanned by men who volunteered for the perilous duty. Thirty-five men had already been lost in her when she sallied out to attack the "Housatonic." Then, after the war, when divers went down to the wrecked ship, they found the "David" wedged into the very hole she had made, evidently sucked in by the rush of water.

The effect of the "David's" torpedo proved that the submarine was worthy of respect, and thereafter there was no more talk about its being "infamous." From the Civil War to our day there has been scarcely a year when an inventor in some part of the world has not taken out a submarine patent.

The result is that the modern submarine is a maze of machinery, with scarcely a square inch of room on the side to spare.

While we wonder at this perfection of the submarine of to-day, we should remember that it is the result of the labor of hundreds of inventors and hundreds of years, with the sacrifice of many lives.

The submarine may not yet be adapted for pleasure cruises like that of Captain Nemo's "Nautilus," but it has at last fought its way to a position among the world's vessels of war.

THE UNDER-SEAS SAILOR AND HIS BOAT

HOW IT FEELS TO GO DOWN IN A SUBMARINE

BY A. W. ROLKER

Ten men sealed inside a gigantic torpedo, now skimming amid sunshine over the glassy surface of a summer sea, now vanishing and diving two hundred feet into the blackness toward an ocean bottom, seeing nothing save a maze of whirling brass and glittering steel, hearing nothing save the deafening drone of hammering, thumping, pounding engines, and all the time tense with the realization that death in one of its most harrowing forms may confront them at any instant—these are some of the experiences of the men detailed to the submarine torpedo-boat service of our Navy. Indeed, the submarine torpedo-boat man combines the hazards of the diver and the "sand-hog"—as the under-river tunneler is called—and takes those of a man-of-war's man and a sailor into the bargain.

Even in time of peace the submariner's life is threatened. For, in order to keep men toned up to the highest degree of war efficiency, the vessels are ordered out for practice frequently, and, wonderful though the vessel is in its possibilities for demolishing enemies, only to an extent can the men inside control what is going to happen to themselves.

Without even a chance of knowing it, the submarine may rise and come to the surface directly in front of the prow of a steamship only to be cut in two like an egg-shell. Often diving farther than the keels of the deepest ocean vessels reach, the submarine is in a strange maritime world where it must take chances in running upon uncharted reefs, or striking water-logged spars or spiles that may meet it head on and lance a hole through the thin plates and hold the boat captive on an ocean bottom. Again, in the frail vessel subjected to an enormous strain while submerged, structural weakness may develop, and the hull may spring a serious leak; or, through negligence, the water-tight cover over the hatch may be improperly screwed down while the crew gazes on, horror-stricken and powerless. And as if these risks were not enough, the men are caged up as if inside the crater of a threatening volcano, for each submarine carries four monstrous torpedoes more than sixteen feet long, each loaded with 190 pounds of guncotton, enough to blow a "Dreadnought" out of water. To these dangers add the fact that when a submarine torpedo-boat sends its deadly sting into an enemy there is the possibility that not a man aboard the boat would live to tell the tale, and you have a fair idea what it means to be a submarine torpedo-boat man.

DESCRIPTION OF A SUBMARINE

No matter how much you may have screwed up your courage, when the time comes to make up your mind to board a submarine boat and take chances, your imagination is apt to run riot. Looking down from the pier from which you

are to embark you see a lead-gray curved surface of steel, which rises above the water like the back of a big whale with a cheese-box hump and a hatch and a pair of ship's ventilators about the middle of it, and a mast at either end. What strikes you most is the insignificant size of the bleak, grim contrivance to which you are supposed to trust your life. All you see is a flat deck-space, twenty-five or thirty feet long, three feet wide at the middle, and tapering to a point at either end, the level of the deck being an absurd twenty-four or thirty inches above the water surface.

As a matter of fact, what you are looking at is the back of a perfectly steerable, mechanical fish, one hundred feet long, and eleven feet at its greatest diameter, built of half-inch-thick steel plates, and provided at the stern not only with the usual vertical rudder with which all boats are steered in a horizontal plane, but also with a horizontal or "diving rudder" by means of which she is made to steer up or down. The tail with which this under-water colossus sends its hull of 170 tons' displacement through the water, consists of twin propeller screws, each driven by a separate high-power internal combustion engine while the vessel runs afloat or awash, and each driven by a separate electric motor while the boat runs submerged. If the captain wishes, he can take you on one continuous run of eight hundred miles, running either on the surface or awash, with his gasolene engines at a speed of thirteen miles an hour; and then he might dive, using his electric motor and storage batteries, and make one long "fetch" of fifty miles, at a rate of nine miles an hour, before his supply of electricity would be exhausted. At the end of these eight hundred and fifty miles he would have to make port for gasolene, would simply reverse his electric motor and run them as dynamos by means of his ship's engines until the batteries were recharged, rendering his boats as efficient as in the first place. No toy, therefore, is this submarine, but a formidable fighting craft, important enough to have induced Congress to appropriate millions to build other submarines like her to be added to the number already on the list of the Navy.

THE IDEAL SUBMARINE MAN

But, gazing down upon the back of this uncanny vessel, which is in reality nothing but an enormous steerable torpedo with a human crew, what interests you most just now are the men who handle the boat and into whose hands you are to intrust your life.

Lounging upon the end of the pier or on the deck of the submarine, the crew little resembles the sort of semi-heroes you might picture as belonging to this service. As likely as not, you are apt to meet a crew not a single one of whom is wearing what even remotely suggests a naval uniform. As a general rule the "captain" wears a uniform, one that is old and weather-beaten, with braid and buttons tarnished by the spray and spume of much salt water. Possibly the ensign or the junior lieutenant, the second in command, is similarly attired. But the three engineers, the two electricians, the gunner and his assistant, and the able-bodied seamen, these are apt to be togged out in "any old thing," from cardigan jackets and civilians' trousers frayed at the ends, down to undershirts and tattered overalls; for the Department recognizes that the submarine service is hard on uniforms, and it is lenient in this respect.

But though the men may appear at first sight disreputable, as a matter of fact you are gazing at one of the most marvelously drilled and disciplined crews of human beings — high-class, picked men, not one of whom has been tried and found wanting. Indeed, the submarine itself sifts the wheat from the chaff. A nervous man, or a man otherwise unsuited by temperament to the work, would wear himself out to a nervous wreck inside of a month, simply by his own imagination. The crew is made up of *young* men, with alert, intelligent, manly faces, young men lured by the very dangers of the work, by the distinction of belonging to that branch of the Navy which is most perilous, by the chances of doing great big things if opportunity only will offer, and by the love of strong natures for excitement and adventure.

ON THE DECK OF A SUBMARINE

Stepping upon the deck of a submarine you are startled to see how desperately near your feet are to the water. Of course, you have expected something like this at first glance at the boat, but as you actually stand upon the deck, the greatest width of which you could cover at a single stride, and as you gaze at the wavelets leaping up within a foot of your toes, there is a nervous cribbling about the ankles, and you wonder whether you will be seized with giddiness and become unable to resist the temptation of leaping overboard once the boat gets under way. You wish there were a rail around the deck or even a bare inch-high cleat to prevent you from slipping into the water; for there is nothing but the two frail ten-foot masts, and they are where

the deck ceases, being only for the peaceful purpose of showing observers on shore the location of the boat when partly submerged.

Out of the middle of the deck arises the conning-tower, which is the captain's bridge while the vessel runs afloat, and out of which the captain can peer in all directions when the boat runs awash; and telescoped in front of the tower is the eye of the submarine, the periscope. One glance at the conning-tower upsets all your notions of what this contrivance must be like. In shape it resembles a thirty-six-inch-long piece of twenty-inch sewer-pipe, provided with a flat, hinged lid and with a circle of narrow slit windows, two inches wide and three times as long. The lid being open to permit ventilation inside the hull, you can gage the inside diameter of the tower as a trifle less than that of a sidewalk coal-hole, and you wonder how in the world you are going to squeeze through to get into the boat. Really, however, you are not supposed to squeeze through. The inside of the tower is lined with a maze of speaking-tubes and electric wires and compasses and bell-pulls and valves and wheels, the nerves leading from the captain's palm throughout the ship, and these might be injured were the tower ordinarily used as a companionway. Generally, the captain glides in and out of this hole; but the crew descends by way of the hatch.

UNDER WAY

When a submarine gets under way she leaves without fuss or feathers, without any of the ceremonies accompanying events on other war-ships. The submarine lives in the dark, striking without an instant's warning like an adder; and direct and to the point is everything that happens aboard the grim fighter.

Long before you have appeared, the vessel has been tested, as she is tested every day whether slated for a run or otherwise. The engines and the dynamos have been turned over and over, the storage batteries have been tested, each valve, each tube, each wire, each bolt and rivet and wing nut has been inspected as if life itself depended upon it. When the vessel is ready to start, the men simply disappear below, the captain takes his seat on the conning-tower, gives word to cast off and "yanks" the bell-pull leading to the engine-room. Simultaneously you feel a tremor throughout the vessel, a deep bass rumble comes out of the open hatch, and like a thing alive the boat moves forward.

Faster and faster revolve the engines, the rumbling settling into the run of a song, farther and farther and faster and faster moves the craft toward broad water until she is darting forward full speed ahead.

For the first time in your life you get an idea of what a fabulous rate of speed thirteen knots an hour is when viewed from the flat side of a plank with a river licking your boot tops. Twenty knots on the deck of a torpedo-boat destroyer may have failed to impress you, but sledding over the surface of the water on the narrow deck of one of these submarines amply provides for your desire for sensations. Back, back whisks the green water on each side of you as if you were gazing over the stern of a fast moving motor-boat. But there is no suggestion of dizziness, no feeling as if you might be tempted to leap overboard, as might come to you when gazing down a precipice. There is nothing of this save the sane fear that possibly you might misstep and fall overboard to disappear in the trail of the white froth boiling behind in a long, narrow streak. All else is exhilaration and healthful excitement. The wind whistles in your ears and blows against your face and through your hair and into your eyes until you must squint them.

Should the water be rough, or should whitecaps rise, the bow wave over the forward deck climbs higher and higher, fetching up against the conning-tower, smashing into mist and rainbows and dousing you with cool, salt spume and spray. Your one fear is: what would happen were a whitecap larger than the rest to board the deck and drop into the hatch? But this is the captain's affair and he, wheel in hand and calmly alert, sits on the edge of the tower as if carved of stone. Mile after mile he sits gazing into the distance, now and then giving his wheel a spoke or two, the vessel, steady as a church, answering the helm and taking seas as if she were a delicately balanced steam-yacht rather than a devil-fish among the fighters of the Navy.

Running in this wise the submarine might cover her eight hundred miles at one stretch, if seas permit, gunner, assistant gunner, and others of the crew not on duty standing upon deck if they wish, while through ventilators and down through the conning-tower waft drafts of moist, cool sea-air.

Should seas arise and threaten to wash into the hatch the captain simply orders the crew below and the hatch sealed. If he does not mind a bucket of water down the back of his neck, he may stay where he is for a time until the seas become even more unruly, when he may glide down the tower, either leaving the lid open to peer over the edge like a jack-in-the-box, or sealing the lid after him and peering through the

slot-holes—depending upon the roughness of the water.

In case seas continue rising and run so high as to threaten to carry away the ventilators, these are telescoped into the hull and the openings through the deck sealed, when you find yourself safe as if inside a gigantic stoppered bottle tossing on the bosom of the seas, now scaling skyward as if shot out of a rocket, and now tobogganing down mountain sides of water. No gale, scattering wreckage and death on high seas, no hurricane, razing coast cities, can affect this craft so long as there is sea room, any more than seas could wreck a feather; and, barring a severe dose of seasickness that would come to you, you would sit as comfortably as in the smoking-room of your pet liner, the only sounds of the fury without being the swish and wash as seas wash clear over you.

INSIDE A SUBMARINE

Climbing down ten rungs of an iron ladder into the interior of a submarine is like going into a boiler-shop where there is one continuous, deafening, ear-splitting racket, like a dozen trip-hammers clattering a tattoo amid a grind and rumble and thump of machinery as if especially designed to burst your ear-drums. At first the noise in that narrowly confined space is painful and bewildering. To make yourself at all heard you must shout into the ear of a companion. So intense is the strain that you marvel how day in and day out human ears can withstand the ordeal.

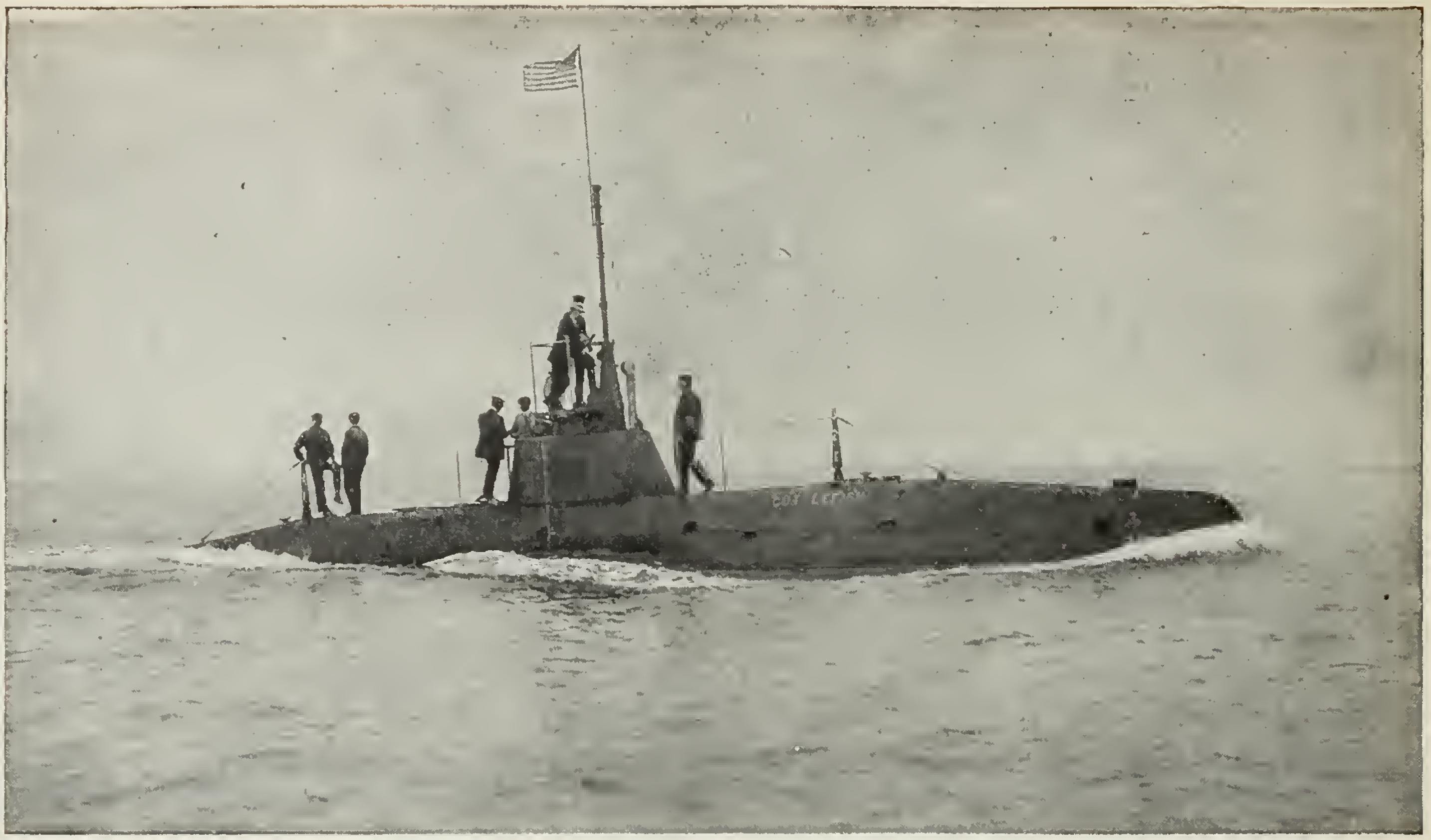
You find yourself inside what seems an enormous steel cigar, painted a neat pearl-gray, a color which is serviceable and does not dazzle the eye. Light comes to you partly through port-holes and in part from incandescent lamps placed fore and aft in the darker parts of the hull. You have expected, of course, to land in a tangle of whirling machinery that fills the inside of the boat from stem to stern, threatening with every revolution to take an arm or a leg off. Instead, the first thing you see is an uninterrupted "working space" or deck, measuring seven feet by twenty-five or thirty feet. At the stern, far in the background, are the machines and engines; in fact, this section of the vessel is nothing but machinery, a rumbling mass of silvery steel and glittering brass revolving at the rate of five hundred times a minute, so compact that you wonder how the various parts can turn without conflicting, or how it is possible for human hands to squeeze through the maze to oil the machinery.

But this economy of space is as nothing to what you will see. The floor you stand on is a cover for the cells of the storage batteries wherein is pent up the electricity with which your boat will propel herself when she runs submerged. The walls amidships and the space in the bow are gigantic ballast tanks to be filled with water that will play a part shortly when you get ready to dive. The four torpedoes, measuring sixteen feet three inches long, eighteen inches in diameter, and weighing fifteen hundred pounds each, are lashed end for end in pairs at either side, and directly over these are tool-boxes, and hinged bunks for the crew to sleep in. The very air which is taken along to keep life in you in case the boat should be detained beneath the surface longer than usual, is compressed in a steel cylinder to two thousand pounds per square inch —a pressure so intense that were the cylinder to spring a leak no larger than a pin-hole, and were the tiny stream of escaping air to strike a human being, it would penetrate him through and through and drill a hole through an inch-thick board behind him.

And yet everything about the interior arrangements of this boat is so simple that you can see at a glance its purpose. Away forward, where the tip of the cigar comes to a point, are the two torpedo tubes out of which the gunner will send his deadly projectiles seething beneath the waters at the rate of thirty-five knots an hour against an unsuspecting hull. Directly under the conning-tower is a platform three feet square and elevated three feet from the deck, upon which the captain stands, head and shoulders extending into the tower so that while at his post he is visible to the crew only from the waist line down; and at the feet of the captain, and on a level with his platform, is the station of the second in command, in charge of the wheel that controls the diving rudders and the gages that register the angle of ascent and decline, and show how deep the boat is down. The two officers are in personal communication so that in case of heart-disease or other mishap either can jump to the other man's place.

"DIVE!"

The order to dive is the peal of an electric gong that clamors high above the racket of the engines, and is most likely to come when you least expect it and while the boat is proceeding on the surface, hatches, ventilators, and conning-tower wide open. Within two and one half minutes of the sounding of that signal, the boat is supposed to have vanished utterly from the surface; and what takes place within that time happens too quickly to be noticed. With the first stroke of the alarm the air is as if surcharged



A SUBMARINE ON THE SURFACE, AT CRUISING SPEED.

with electricity. Men are everywhere, each running to his post. The engines cease to revolve. The engineers sever the couplings between the engines and the shafts and connect the shafts with the electric motors. The electricians are at their switchboards awaiting only the word to turn on the current. The gunner, the assistant gunner, and the able-bodied seamen screw down hatches and take in the ventilators. The junior officer, diving-wheel in hand, turns on the valves which admit floods of water into the ballast tanks.

You hear the water as it gurgles and seethes into the tanks, and you hear the displaced air whistling out of the valves on top. You feel the decks settle under you and realize you are going down, just as you would feel this in an elevator cage lowered gradually. As the sinking proceeds, if you look at the portholes, you can see as the level of the water reaches the glass and rises and rises until instead of daylight there is a green-gray mist and you continue to sink until, the ballast tanks having been filled, only two inches of the deck are above the water's surface—the submarine is awash.

THE SUBMARINE *OCTOPUS*, DIVING.

Briefly, what the men have done is to destroy the buoyancy of the boat by admitting water, so gaging the cubical contents of the ballast tanks that the vessel is balanced so delicately that of herself she will come to the surface showing only two inches above water, while all that is necessary to send her under to any desired depth within the fraction of an inch is the mere declining of the horizontal rudder at the stern. In fact, your vessel is so balanced on a hair-trigger edge that the weight of four 200-pound men would send her under, and so delicately balanced that were it possible to look through the bottom of the boat into the depths beneath, its keel might be brought against the glass of an open-face watch in place without breaking the crystal.

As the electric motors begin to buzz and hum, sending tremors throughout the boat and forcing her ahead, there is no sensation of motion. The vessel might be standing still or might be moving backward for aught you can tell. You have lost your ability to discern either speed or direction, for there are no stationary objects by which you can gage position. As the diving rudder is set you can see and can feel as the nose of the vessel declines, just as you can feel with your eyes closed in which direction a see-saw you are standing upon might be tilted.

ANOTHER VIEW OF THE *OCTOPUS*, DIVING.

Smoothly and evenly, as if you were gliding down a hill in a trolley-car, you feel your boat tobogganing into the depths. You hear the water as it breaks against the conning-tower, hear the swish and wash of the waves as they climb on deck, and hear the seething as they angrily close over you. The boat might glide into the depths decorously at an angle of four or five degrees; or she might seem to kick up her stern and lower her nose threatening to turn a somersault and dive at an angle of twenty degrees, but the sensation would be no more disagreeable than coasting. All you see is that the deck is correspondingly declined. This, and the fact that the gray-green against the port-holes is steadily darkening until, as you reach a depth of twelve feet, all you see is inky black, so that below this depth you cannot tell excepting by looking at the depth gages whether you are twelve or thirty or two hundred feet down.

THE CREW AT WORK

NOT until you have gone down in a submarine and seen the crew at work can you say you have seen the limit to which it is possible to drill human creatures. No crack company of a regiment, no fire company in any of our big cities, not even the engine force on a man-of-war is under such discipline as the crew of a submarine.

The Navy Department and the men themselves realize that months are required before even the most capable group of ten can be made to work as a unit, perfect as clockwork. There is no time to "break in" crews when once war is declared, and for this reason the submarine service is continually and incessantly in war practice. Practice runs in the ordinary sense do not exist. Each time the boat stands out to sea she goes as if for business, the scenes you see being exactly like those that would

be enacted were the vessel bent upon actually sinking an enemy.

When a submarine leaves her pier under her own engine, orders come fast and furious; but once she is ready to dive they become almost incessant. In order to train men to keep in practice at their various duties and to perform these almost subconsciously, every manœuver which the vessel performs is repeated again and again. On a single afternoon's run, for instance, the boat may be brought from her light to her diving condition as many as a dozen times, so that actually the crew has no time *except* to attend to business. In the hand of each man rests the lives of his companions. More, it is conceivable how in the palm of a single man might rest the fate of the nation. Every man, from the captain who ranks as a lieutenant, to the able-bodied seaman taken from the forecastle of a warship, is at his post, tense, alert, with lips set and eyes and ears wide open, for the time being not a human creature but just a part of a marvelous machine. Not a word is spoken. Not an eye is found roving. Each man is a mere cog, a human, thinking, intelligent cog, nevertheless, a mere cog.

THE SUBMARINE *CUTTLEFISH.*

What the submarine does, once it has disappeared, depends, of course, upon the captain. Steaming forward she can turn completely within three times her own length and running backward she can head completely around in a single length. If the captain wishes, he can sink the deck an inch or a half inch or a foot or ten feet beneath the sea and proceed on an even keel, appearing from the deck of a man-of-war a mile and a half away like a chip of wood floating over the water; or he can go down ten feet, showing only the flags on the tips of his masts and proceed on such a level plane that the wire stay, running between mast-tops, is right down to the surface of the water. Or, if he wishes, he can rise and dive and rise and dive, "breaking" his conning-tower at intervals of half his boat's length, like a porpoise at play, while you sit still and feel yourself alternately climbing and coasting and climbing and coasting, rays of sunshine

alternating with the green water through the port-holes, and the splash and the seething of the water aboil coming from overhead.

THE EYE OF THE SUBMARINE

It is while running under water, of course, that the submarine encounters her gravest dangers, for the submarine is her own worst enemy. Largely, then, the captain must steer by compass and estimate distances covered by computing the revolutions of the propellers and he must take chances on being swept out of his course by unknown currents and cross currents. From the instant the slit windows of the conning-tower go under, these show only the green of the water, and when twenty feet depth is reached, looking through these windows is like trying to penetrate a sheet of jet. In order to enable the captain to see what is going on upon the water surface he is provided with a periscope which is nothing but a *camera lucida* on the principle of the "finder" of a camera, mounted on the top of a four-inch telescope-tube which can be extended twenty feet upward from inside the conning-tower, and down which the camera deflects against a six-inch diameter white enameled disk the diminutive images of whatever goes on above. The periscope, however, is useless when the boat dives deeper than the length of the telescope pipe, and, besides, it takes in only forty degrees of the horizon at a time, thus showing only a section at which it is pointed. For these reasons, likely as not, the captain may ignore the periscope entirely, using it only to practise running submerged toward a given point, while for actual navigation purposes he depends solely upon coming to the surface at intervals of two or three miles for a hasty look around. All of which shows in a measure the helplessness of the submarine—a terrific, dangerous, grim monster in itself, but one that can only partly see.

ON AN OCEAN BOTTOM

Up to now, however, you have not seen in full the possibilities of a submarine, for although in rivers or harbors the shallowness of the water limits the boat to traveling within ten or twelve feet of the water's surface, once at sea the vessel dives deeper.

As the nose of the boat touches the broad ocean you require neither slit windows nor periscope to tell you where you are. Caught in the swell of the sea, the boat heaves and falls, heaves and falls, and unless you have your sea-legs on, you are as apt to be seasick in a submarine as you would be inside any other vessel, or more so. None, not even the most hardened submariner aboard, covets the sensation, and to overcome it the vessel dives deeper, twenty or twenty-five feet down, at which depth even the strongest wave-motion on the surface cannot be felt. Overhead might be seas mountain high threatening even a *Deutschland* or an *Adriatic,* yet twenty-five feet beneath the ocean surface you would proceed unmolested as if traveling beneath a mill-pond.

But twenty-five feet beneath seas is by no means the limit to which your boat can dive; in fact, at this depth she has not begun to dive. If your captain wishes, within two minutes he might take you down two hundred feet—fifty feet deeper than the most skilled deep-sea diver dares to venture—and where against every square inch of the surface of your boat there is a crushing pressure of more than 133 pounds. This, in truth, is one of the tests the government insists upon. If desired, your boat might dive to this depth or to any intermediate depth, and lie perfectly still like a gigantic fish of prey. Or within this depth limit she might come to rest against the very ocean bottom, landing light as a maple leaf wafted down upon a lawn.

Sitting inside a submarine on an ocean bottom you would be no more conscious of the enormous water pressure without than if you were going to sleep in your own bed. You might remain twenty-four hours under water without coming up, using only the natural air supplied in the boat without feeling the least uncomfortable. If you wished, you might remain down four or five days, tapping the air tank as you needed a fresh supply of air. In the meantime you would bunk over the torpedoes and torture yourself by letting your imagination loose to your heart's content, or you might read by electric light or play cards or dominoes or checkers, the cook serving you with coffee and canned things that can be heated on an electric furnace without causing too much smoke, and making the air disagreeable to breathe.

Lying there, beneath the water, you are indeed cut off from the world. Hurricanes, typhoons, snow or sleet storms and blizzards might rage above you, and you never would know it. The entire American navy might assemble over your head and fire one simultaneous, ear-splitting, earth-quaking salute that would be heard twenty miles away, but you would not hear it. Nothing would come to you save the underwater noises: the thudding of propellers of steamers overhead, the chafing and banging of spars on decks of a wrecked vessel not far off, the grind and the crunch of your boat's keel scraping the sands.

THE SUBMARINE IN ACTION

INTERESTING though it may be to lie in a submarine two hundred feet down on an ocean bottom, this is a test which the Navy Department insists upon only as a practical test to insure that your boat is structurally of a certain standard. Ordinarily, even during war time, the submarine would not be called upon for such circus "stunts," even though awaiting the arrival of an enemy off a sea-coast. Then, cruising light, the boat would hover on one side of the lane by which the hostile ships must enter, sighting a war-ship eighteen miles distant, long before she herself could be detected by powerful glasses.

SIGHTING THE ENEMY WITH A PERISCOPE.

Full speed ahead the submarine would dart, laying her course to intercept the enemy, letting herself down as she drew nearer until she is awash at two miles distant. Then, torpedoes in tube, electric motors whirling, and crew at fever heat, down she goes until within one and one half miles of her prospective victim. "Porpoising" at intervals of three fourths of a minute, breaking her conning-tower for five seconds, she would proceed until within eight hundred yards, where she would rise to the surface, head her nose at the broadside of the enemy, let drive her torpedoes, drop under at once, listening for the frightful crash as the dread missile explodes its one hundred and ninety pounds of guncotton against the hull of the ship.

During the Great War the German submarines became known as "the devil-fish of the seas." Their use against ships of war was legitimate and even, with restrictions, against other vessels, but when they were used to send to the bottom peaceable neutral vessels carrying helpless men, women, and children the world rose up in horror against such a practise. It was such acts of "frightfulness" that finally brought the United States into the conflict, and sent its navy and army "over there" to fight for freedom.

HOW KNIVES CUT

BY C. H. CLAUDY

WITH PHOTOMICROGRAPHS BY THE AUTHOR

What makes a sharp knife cut, and a dull one hard to use? At first glance it would seem that the thinner the sharp edge, the easier the knive would cut, and in a measure, this is so, yet there are exceptions. If you want to carve a roast of meat and are offered the choice of a sharp carving-knife or a sharp razor, obviously you will choose the former. Yet the naked eye can see that the edge of the carving-knife is much thicker than that of the razor. When you come to the bone, it is not a knife, no matter how sharp, that you want, but a saw, as saws have very thick edges, provided with teeth.

Another puzzle—why, after a penknife is carefully sharpened on a stone, will it sometimes hold its edge for a long time and, again, get dull in a day?

Almost without further words, the little pictures answer these questions, once you know what they are. They are photographs of knife-edges, taken through a powerful microscope, which has magnified the edge so much that it no longer seems a smooth edge but a rough, irregular saw. And that is the secret—knives, no matter how carefully sharpened, are little saws; the grinding away of the steel, done by the stone, is not an even work, but when the edge gets thin, is a process of tearing away tiny bits of steel by the grit of the stone. This tearing makes the teeth. A fine stone makes fine teeth, a coarse stone coarse teeth. A carving-knife, used on meat, is sharpened on a coarse stone or a steel, and has coarse teeth, although its edge is thick. Its action in parting the meat is more that of a saw than a fine wedge. No matter how soft it may be, it will not cut easily unless it is drawn over the meat and not simply pressed down. A razor, however, with its paper-like edge, will cut into flesh with a simple pressure—it is a wedge dividing the fibers of flesh just as a wedge of iron divides the fibers of the log it splits. But a razor is a saw, too, only, as it is ground on the finest stones and later finished with a leather strap, its teeth are very fine indeed—hundreds and hundreds to the inch of blade. In the original photomicrograph, as I made it, the bit of razor which was under the lens was only one one-hundredth of an inch across, and you can count as many as twenty-five irregular teeth in this space. Here, also, is the explanation of what some people consider a fancy—that one razor will cut better on a certain beard than another equally sharp. Obviously, the tougher the beard, the finer the teeth must be to cut without "pulling," and a "pulling" razor is one which has teeth too coarse for the hair it aims to shave.

When you sharpen a jack-knife on a grindstone and finish it up on an oilstone, you have a sharp edge for a while—for a *long* while, if you have done the job rightly. But if you have ground with the blade very flat on the stone and the blade is, consequently, very thin indeed near its edge, you will probably have made what we call a "wire-edge." One of the photographs shows this wire-edge. The steel has been cut into little saw teeth, it is true, but they are so thin that they break easily—how thin the steel is can be guessed from the little holes in the edge

THE EDGE OF A NEWLY HONED RAZOR-BLADE.
(Greatly Magnified.)

which have been torn by some extra large and sharp piece of grit in the stone. A wire-edge is very sharp, for a short time, but the teeth break off with every use of the knife, and, before you know it, only a jagged edge is left, which is neither sharp nor smooth.

Don't hold a knife flat on the stone—hold it at an angle so that from an eighth to a quarter

A PROPERLY SHARPENED PENKNIFE.

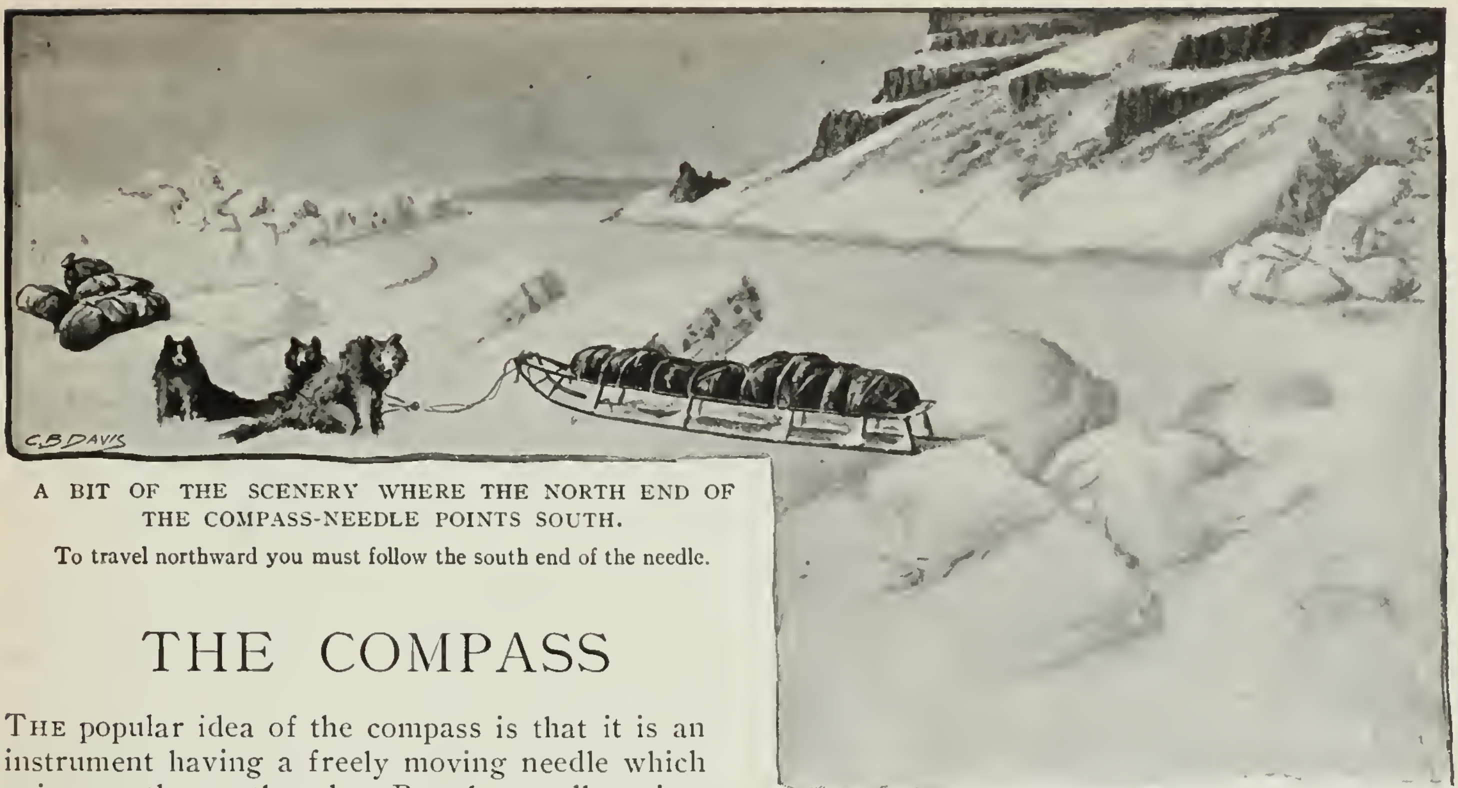
of an inch of blade is being ground, and when you put it on the oilstone, hold at the same angle. This will give just as fine teeth, but they will be thicker at their base than those made the other way—they will not break off so quickly and consequently the knife will stay sharp longer and may be given harder usage.

A saw, such as is used on wood, may be taken as an exaggerated knife. When you see a carpenter cut across the grain he takes a finer toothed saw than when he rips with the grain. *Across* the grain, he meets with the resistance of the fibers, which catch in the teeth; *with* the grain there is less of this action and a coarser tooth can be used with better results. Knives are just the same—a knife may be very sharp for some kinds of work and very dull for others—for instance, the carver and the razor for the meat-cutting referred to at the beginning. The carver is sharp for the meat, where much pressure and little resistance are to be found, but imagine trying to shave with one! Hair is very tough indeed, and where so little pressure can be used as in shaving, the sharpest kind of a knife is required—which means only with the very finest and thinnest kind of teeth.

Have you ever cut yourself with a piece of paper? The edge of a piece of glazed paper looks much like that of a knife under the microscope. Of course, the little teeth have not the strength of steel, but if the edge of the paper is drawn swiftly over the finger without much pressure, that peculiar property of matter called inertia comes into play, and the tender teeth have cut the flesh before they are broken. The same property it is which allows a candle to be shot through a one-inch plank, or permits a bullet to pass through a pane of glass without shattering it, leaving only a clean, round hole.

I wish I had space to show you some photomicrographs of the knives of insects; certainly they carry knives, some of them. The horse-fly, for instance, has a ferocious set of lances, compared to which a razor is as a saw to a pocket-knife. The little teeth made by nature are so small, so even, and so sharp, it is no wonder that the little insect can cut (bite) his victims, without needing more pressure than his tiny weight easily affords.

A "WIRE-EDGE" ON A POCKET-KNIFE.



A BIT OF THE SCENERY WHERE THE NORTH END OF THE COMPASS-NEEDLE POINTS SOUTH.

To travel northward you must follow the south end of the needle.

THE COMPASS

THE popular idea of the compass is that it is an instrument having a freely moving needle which points to the north pole. But the needle points to the north pole when the compass is situated on the meridian of longitude that runs through the north magnetic pole. The real (or geographic) north pole and the magnetic north pole are not in the same place.

The magnetic north pole, toward which the compass-needle really points, is situated in the northern part of Canada, in northern latitude 70° 5′ and longitude 96° 43′ west from Greenwich. It was first visited in 1831 by Sir James Ross. The southern magnetic pole is in a corresponding position in the antarctic region. It was discovered by Sir Ernest Shackleton's expedition to be latitude 72° 25′ south and longitude 154° east.

These magnetic poles are not stationary. The northern one is slowly moving westward along the seventieth parallel, and in the course of three or four hundred years will probably have encircled the geographic north pole and returned to about its present location. Of course the southern magnetic pole follows a corresponding course about the geographic south pole.

In such cities in the United States as Omaha, Sioux City, Topeka, Galveston, etc., the compass-needle would point about in the direction of the north star and the north pole that Commander Peary reached. This geographic pole is about fifteen hundred miles north of the magnetic pole, toward which the needles of all compasses point.

When you get to the east or the west of the meridian that runs through these cities, the compass-needle will point a little east or west of north, according to where you happen to be. You can see that if you go eastward of this meridian the needle will point a little *west* of true or geographic north, and if you go west of the meridian the needle will point a trifle *east* of north. Reference to the globe illustration on the next page, will make this plain. Say you have traveled as far eastward as New York city. A glance at the compass placed there will show about how much the needle fails to point to the true geographic north, for it is the *magnetic* pole that attracts it. If you traveled due north (along the meridian) from New York city, your needle would swerve more and more toward a westerly direction until you got to the seventieth parallel, on which the magnetic pole is located, when the needle would point due west; and if you continued north on the same meridian, the needle would point southwest; and so on. If you went north through San Francisco till you reached this parallel, the needle would point due east, as you can see from the compasses, in Fig. 2, located at these points. But suppose you left Omaha and traveled due north along the meridian of the magnetic pole, what would happen? Several surprises would await you. When the needle was exactly over the magnetic pole it would act about as a piece of straw would act and remain pointing in any direction in which you placed it—provided, of course, there were no disturbing local magnetic influences. Now for the queerest surprise! If you wished to continue your journey northward (geographically northward) you would have to be careful not to go in the direction of the *compass's* north,

for after you have passed the magnetic north pole your needle *has swung around* and points to both the magnetic north and the geographic south pole.

The next surprise would be when you reached the exact or geographic north pole and stood on it, for at that point you would know that there could be no east or west—you would look only south, no matter which way you looked—but the compass would point to *its* north just the same, though its north would be really south, and south along only *one* meridian.

It may be interesting to know something about this queer compass of ours whose needle cuts such strange capers. What is it, how was it discovered, who discovered it, etc.?

First, the compass is an instrument for indicating how many degrees east or west of a certain chosen meridian any point may be. The name *compass* probably meant originally (as a Latin word, *compassus*) a circle (such as is made by the drawing-instrument called a *pair of compasses*), and was given to the magnetic instrument from the fact that its needle or card will encircle, or compass, the whole plane of the horizon and indicate the whole circle of possible horizontal directions of all points on the earth's surface.

The ship's compass is composed of three parts, as follows: first, the bowl or case; second, the card; and, third, the needle. The bowl is usually a brass receptacle suspended by two concentric brass rings (shown in Fig. 3) so joined as to keep the compass horizontal, no matter what may be the position of the ship. The circular card is divided into thirty-two equal divisions, the four main ones of which are the cardinal points of north, east, south, and west. The card is balanced from a cup-shaped agate center resting on a hard-metal pointed pin. The magnetic needles, usually two or four, fastened on the under side of the card, are composed of magnetic rods formed of thin layers of steel or of bundles of steel wires. On shipboard the compass is inclosed in the top of a stand called a binnacle. In Ritchie's liquid compass the card floats on the surface of a liquid composed of alcohol and water.

Young folks may quite easily make a compass of this form. Magnetize an ordinary sewing needle by rubbing it on a simple, "horseshoe" magnet.

If a heavy needle is used, float it on a card or a slender strip of wood of the same or nearly the same length as the needle. If a light needle is used, and it is well rubbed by the fingers, or slightly oiled or greased, it may be carefully laid directly on the water. Though the needle is heavier than water, it will float because its weight is not sufficient (if either point is not tipped downward) to break the surface film of the water and sink.

The earliest accounts of the compass in Europe, it is thought, date back to the twelfth century.

FIG. 1.

In 1597 William Barlowe says regarding the compasses then in use by the East Indians:
"Instead of our compas they use a magneticall needle of sixe ynches long and longer, upon a pin in a dish of white china earth filled with water. In the bottom thereof they have two crossed lines for the foure principall windes."

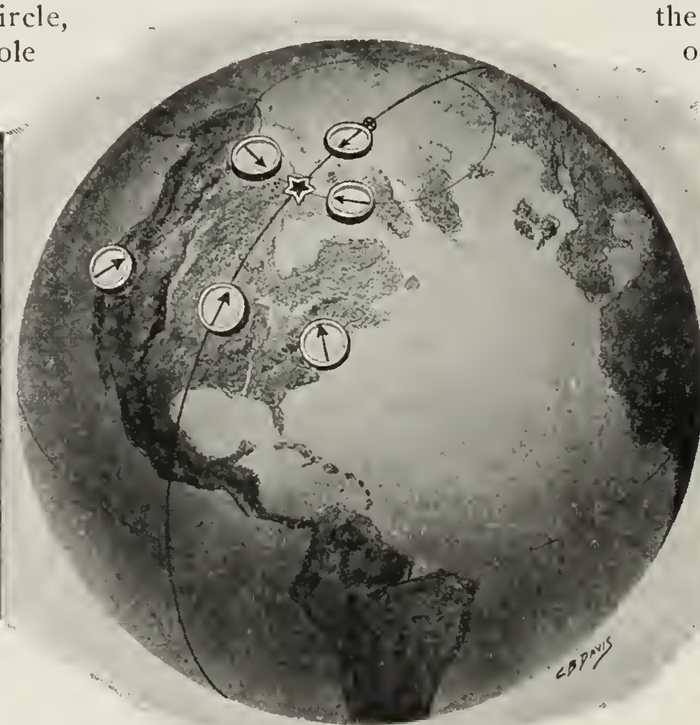


FIG. 2.

Compasses located at various points in the United States to show the variation of the needle.

FIG. 3.

A modern compass with part of the box broken away to show pins in the rings (gimbals) to keep the compass horizontal.
The principle is practically the same as in earliest compasses that were merely splinters of wood supporting magnetic needles. The disk is kept "water-level" by gravitation, while the needle points to the magnetic pole.

THE BUILDING OF A "SKY-SCRAPER"

BY FRANCIS ARNOLD COLLINS

A QUAINT story is told of an old architect of the Middle Ages who prepared his plans for a great cathedral by sitting silently before its site for several years, smoking and meditating upon his work, before he drew a single line upon paper. The construction of a modern sky-scraper goes ahead astonishingly faster. The great steel structures, which are so characteristic of American ingenuity and energy, are built more after the manner of Aladdin's palace.

When the builders receive a definite order for such a structure it is a question only of hours before it will be actually under way. Before the architect has touched pen to paper, or perhaps before he has found time to give a thought to the design of the building, gangs of workmen have probably been rushed to the site to begin the preliminary work.

Should it be necessary to tear down a building it is quickly attacked, so that a few days after the order has been received the site will be marked by a cloud of dust. Even when a great steel structure is to be built upon a vacant lot the workmen are hurried to the place, the ground will be cleared, and the preliminary work will soon be well in hand. It is not a question of deciding upon a date a week or a month in advance to make a beginning. In most cases the work is actually under way before the sun is set.

Meanwhile a great staff of assistants lined before long rows of desks are busily at work figuring on the general form of the building, the weight the floors will support, the size and form of thousands of pieces of steel used in the construction, the quantity of stone, wood, and plaster, and the various materials employed. As soon as the builders know the height of the building, the number of stories, and its general form, they are able to order a great deal of the material needed, so that valuable time may be saved. It is not so much a question of saving material, or the cost of labor, expensive as these may be, but of saving *time*, which in busy streets, and when so much capital is involved, is very costly.

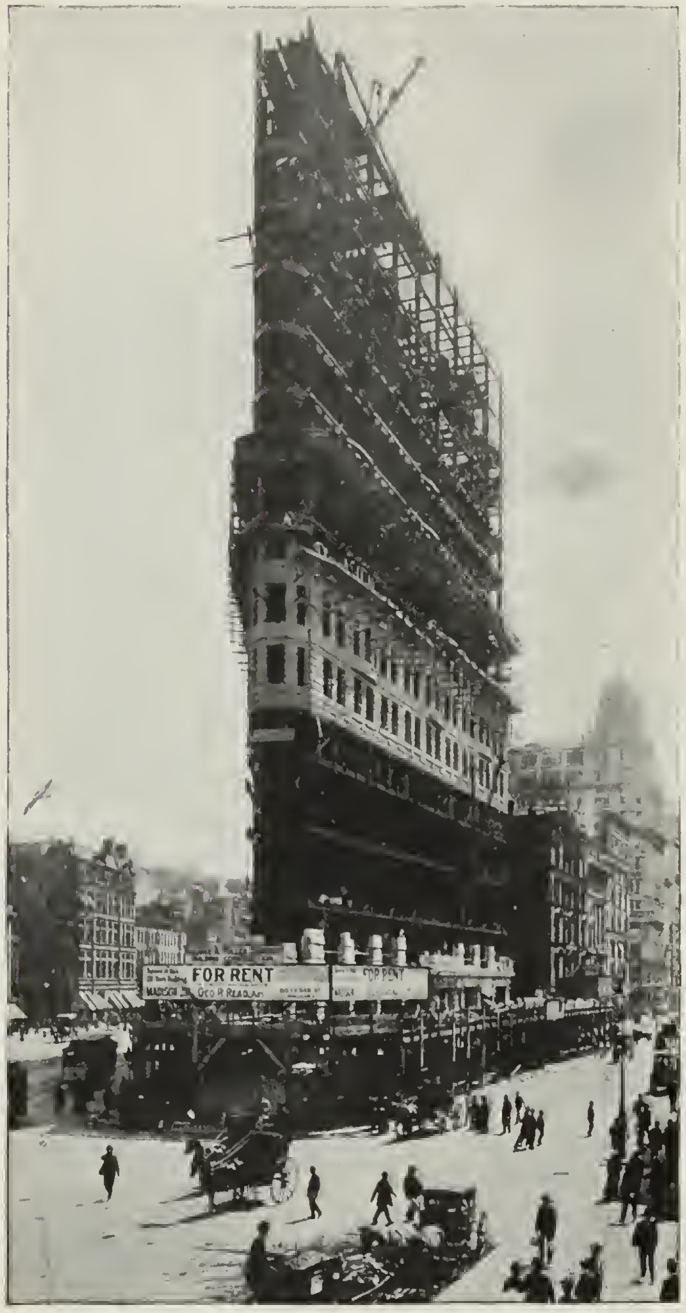
Each department is, of course, carried on by men skilled in their line, and these men must be gathered and employed. Orders must be sent to the quarries, perhaps hundreds of miles away, for the necessary stone. The lumber mills must also be told just what the orders will be so that they may get to work. In addition there are plumbers, electricians, plasterers, carpenters, decorators, and hundreds of workmen to be engaged, all as far as possible in advance.

It is only a few years since the first work in erecting a building was to dig a deep hole for the

TWO MEN IN A BUCKET ENTERING A CAISSON.

foundations. If the building was to be a large one the excavation had to be very deep and wide. Large gangs of workmen with carts and horses were employed. It would frequently happen that great masses of stone must be blasted and, with the sand and dirt, carted away. Until this great hole was completed everything was at a standstill. To-day all this is changed. As soon as the site for a sky-scraper has been cleared for a modern steel structure, the ground is quickly filled with powerful machinery which would not

have been dreamed of by the builders of a few years ago. In many cases the site is actually floored over with heavy timbers before the work commences. The machinery, which is quickly



"WALLING-IN." THE "FLATIRON" BUILDING, NEW YORK CITY.

assembled, consists of powerful derricks, great drills, chutes, tall engines, odd-looking machines for mixing cement, and many curious steel frames to be used for building the odd chimney-like "caissons," as we shall explain later on. Such groups of machinery may be seen to-day in the most crowded streets of all large American cities.

For many centuries, in fact since the first stone buildings were raised by man, the general plan for building foundations has been much the same. It consisted merely in building a wall deep enough and wide enough to support the structure above. When a very large building was to be erected, a cathedral for instance, the foundations were simply made deeper and wider. The plan of building foundations by means of caissons, which is an American idea, is of very recent origin. These foundations consist of pillars of artificial stone extending down into the ground, a great many of them for a considerable distance. These pillars, which form the foundation, are run down into the earth till they rest upon solid rock or at least a very firm basis. A building of twenty or twenty-five stories, for instance, usually rests upon foundations extending about sixty feet below the surface, and in some cases in New York, as far as eighty-five feet, depending upon the nature of the earth.

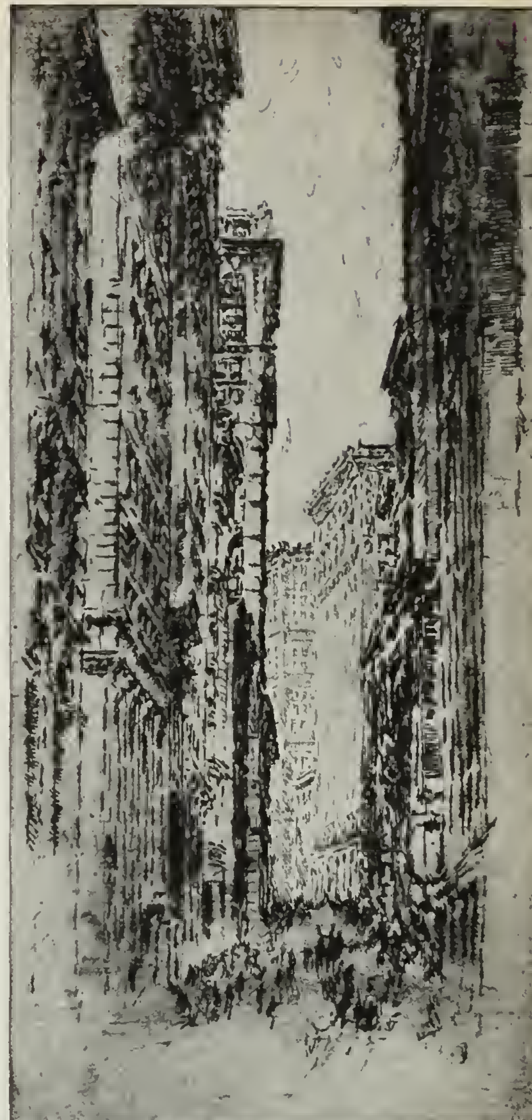
The foundations for the great steel structures are built by means of caissons in which the men can work under a great pressure of air. It is a very interesting sight to watch them, and the best of it is that any one may see them at close range from an adjoining sidewalk. The caisson is a hollow steel cylinder open at the bottom and just large enough to permit a man to work. The workman climbs down a ladder in this tube and digs away the earth at the bottom. As the earth is taken away the steel tube is gradually lowered. The earth is taken out by a bucket which is lowered and raised by a tall derrick at one side. As the caisson sinks, air is pumped into the compartment containing the man. This is to force back any water or dirt that might fill the hole from the outside as fast as the workman removes it from within. The pressure of this air is often so great that a man can work but an hour or so at a time. At the top of the caisson is a steel cylinder with an air-tight door at either end which serves as a kind of vestibule to the tube below. When one of the caisson workers starts to go to work he opens the door or lid at the top and climbs in, when the opening is once more tightly closed. This door or lid is air-tight. After the opening to the outer air has been closed the workman opens the door at the bottom of this steel compartment and lets in compressed air from the caisson below. It takes a few minutes to become accustomed to breathing this atmosphere, for the heavy air makes the head ring. As soon as the workman can do so he climbs down into the funnel below, closing the lower door of the steel ante-room as he does so. All this must be done in the dark. If the workman wishes to signal the outer world he may do so by striking the steel sides of his narrow prison

THE REMARKABLE "FLATIRON" BUILDING AT MADISON SQUARE, NEW YORK.

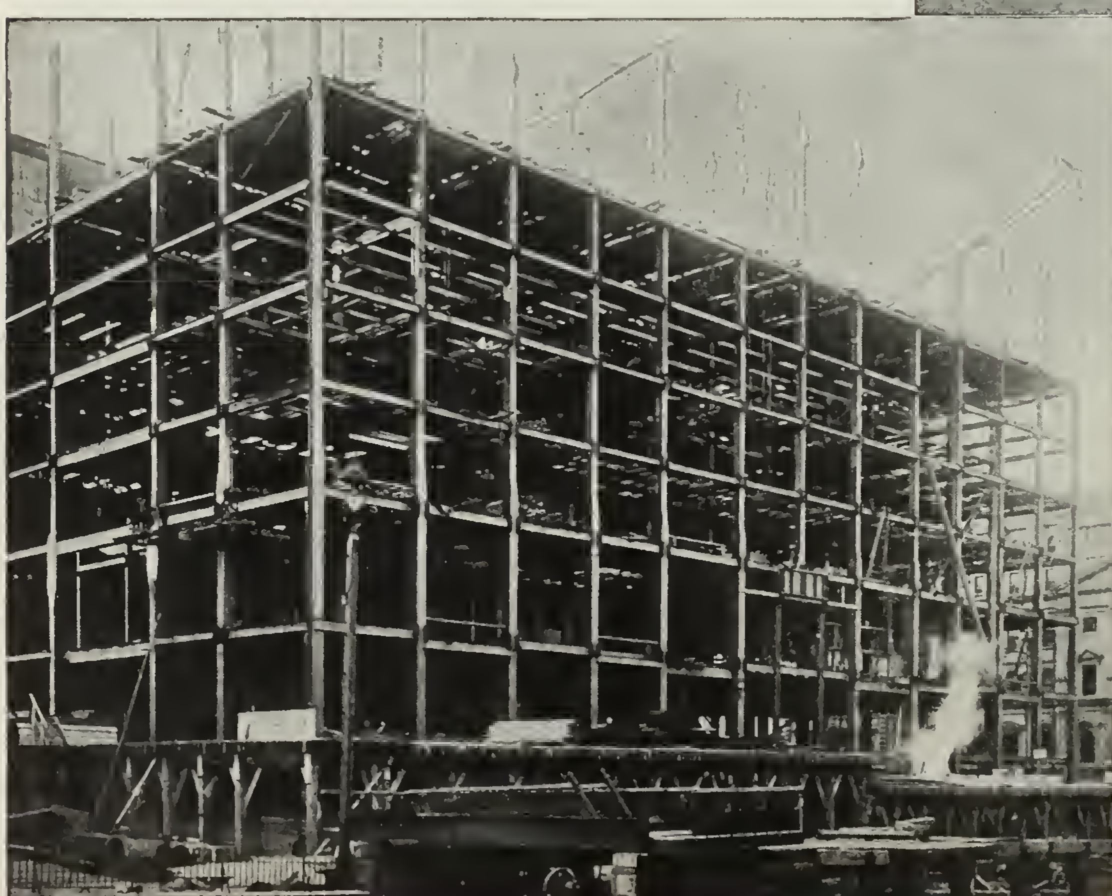
with his shovel. He usually signals in this way when the bucket is to be raised or lowered.

The work on one of these sky-scrapers goes forward so quickly and smoothly that few people realize how difficult is the problem to be solved. When the ordinary house is to be built, the bricks, stone, and lumber are piled about to be ready when needed. Now the steel structures with the tons and tons of material for all their great bulk are almost always built upon the busiest and most crowded streets of large cities and have literally no room to spread out. The streets and not even the pavements can be blocked even for a few hours. This fact, which few people stop to consider, makes the task exceedingly difficult. The work must be so arranged that the thousands of steel girders, the tons of bricks, stone, and lumber will be delivered only as it is needed and a day or two's supply at a time. Everything must move like clockwork. The directions for the work on such a building read like a time-table. If, for instance, the cement for the foundation should be but a few hours late in arriving, the entire force might have to stand idle. Should one of the steel girders be late or be delivered out of its turn, the iron-workers and all the men who depend upon their work would have nothing to do. The work goes forward so fast that every part depends upon something in one or more departments. And since as many as fifteen hundred men are employed on one of these steel structures at the same time, the loss of a day or so would cost thousands of dollars.

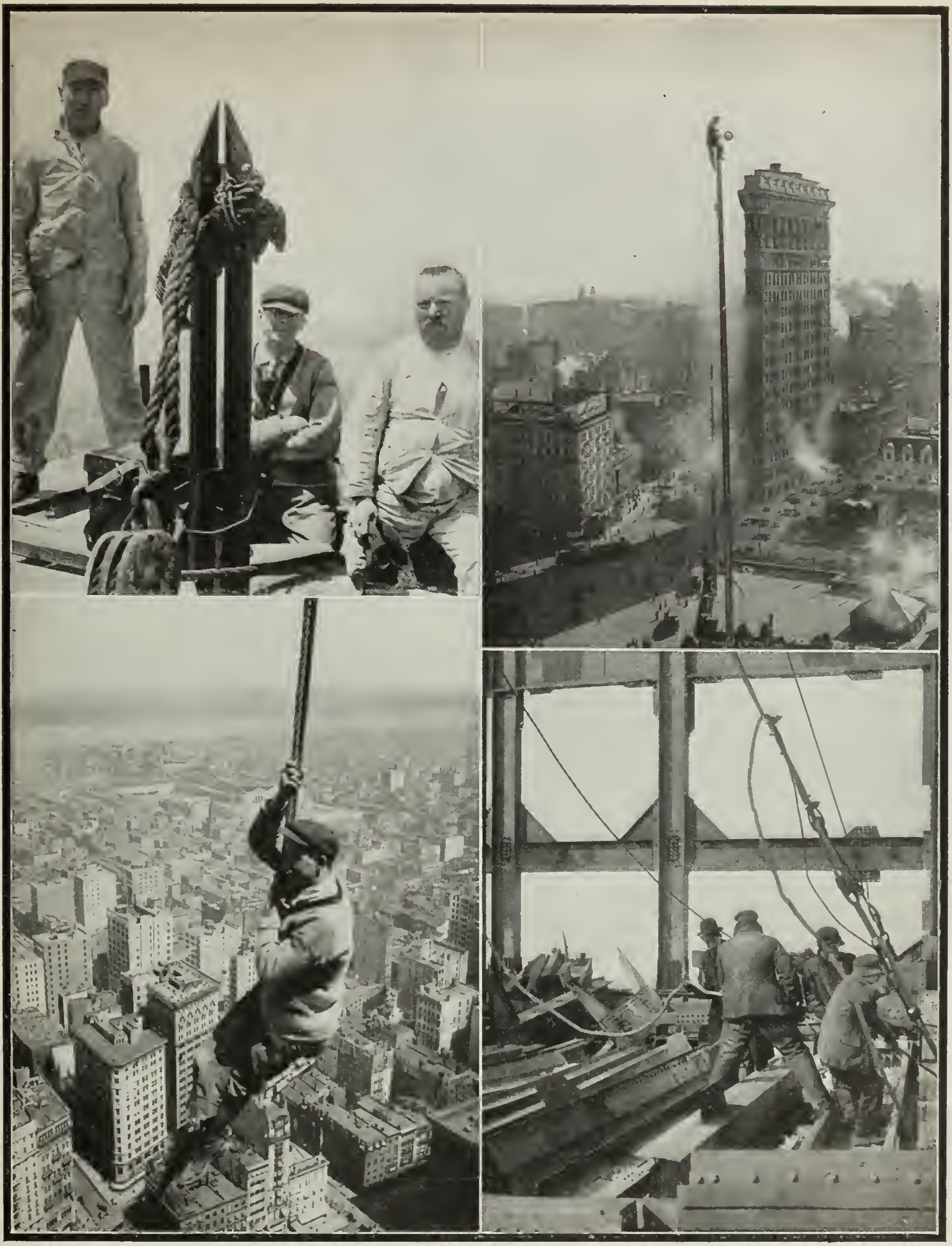
It has been asserted that Solomon's Temple, which was considered a great building in its day, was so constructed that when the materials were brought together they fitted perfectly, and so the structure rose without the sound of a hammer. A modern steel structure, which is vastly more complicated, is built in much the same way, every part, though it be made hundreds of miles away, fitting into its place. There is a great contrast, however, about the sound of the hammer, for the steel building must be securely riveted together. The builder first calculates exactly what each floor will be called upon to support and from



"THE CAÑON," WILLIAM STREET, NEW YORK CITY.



THE FRAME OF A MODERN "SKY-SCRAPER."



MEN WHO WORK ON "SKY-SCRAPERS."

Dangerous indeed is the life of the men who put together our towering buildings. Hundreds of feet in the air, often on the narrowest supports, they do their daily tasks with a coolness that makes the onlookers gasp. These pictures show men working upon the gigantic Metropolitan building, New York City. The picture on the upper left-hand side is that of the top of the tower of that building, showing the lightning-rod. The picture on the upper right-hand side shows a man at the top of the flagpole of the Hoffman House, New York.

this he will know the size and shape of the girders to be used. These he orders at some steel-works, probably hundreds of miles away, while he fixes the exact date when they are to arrive. It is the same with the stone, the bricks, the wood, and the many other materials. When these materials arrive, perhaps from all over the country, each piece will be marked in somewhat the same way as the material of Solomon's Temple, so that each may be put in its place.

The rapidity with which these structures rise is always a surprise. They seem to spring up almost in a day. As a matter of fact, under favorable circumstances, one of the buildings rises at the rate of about four stories a week. The finishing of them will of course take much longer. First the steel uprights are raised by the powerful derricks and swung neatly into place, while a gang of workmen, as many as can work together, quickly rivet and bolt the steel bars. The rivets are heated to a bright red heat, while the workman, sitting astride the cross-pieces, perhaps hundreds of feet above the street, hammers away till the great network rings like some giant smithy. In a few days a great forest of steel has sprung up, open on every side to the wind and weather.

The most astonishing thing about these huge structures is to watch them rising against the sky without walls of any kind. The steel network supports the building and the walls are merely a shell to be hung to this later on. And so we see these buildings with their walls beginning at the fourth floor and with the iron skeleton below entirely open. The steel buildings, however, are not the first to be built in this way, although the idea of doing so originated in America. The steel sky-scraper is, after all, the outgrowth of the old American frame house. Ordinarily a building rests upon its walls; the old-time frame house was held up by its frame, and the walls, whether they were of shingles or clapboards, were nailed on afterward. The quaint old-fashioned houses of a century ago would probably not claim to be relations of the gigantic steel buildings of to-day, though the family resemblance is unmistakable.

As quickly as the steel beams are in place in the sky-scrapers the masons are hurried to their work. The plan generally followed is to keep the stone-masons, housesmiths, and plumbers one floor behind the iron-workers, the carpenters one floor behind these, and, one floor behind these, in turn, the plasterers, and so on till the work is complete. In every department of the work again are to be found ingenious time- and labor-saving devices. The scaffolding used by the bricklayers in walling-in, for instance, is well worth watching. The builders of a generation ago were obliged to set up a heavy scaffolding which had to be raised with great trouble or be added to as the wall rose. It was a common sight to see a large building completely covered with such staging. The scaffolding of to-day, on which scores of men may work at the same time, swings clear of the walls and is held by wire ropes which run to a point eight or ten stories above. These ropes are held by an ingenious device in the form of a pulley which makes it possible for one man to raise or lower the entire platform ten stories below. As quickly as a layer of stone or brick is laid the platform is raised so that not a moment is lost.

The hod-carrier of a few years ago has disappeared, as has his ladder, and in his place will be found a series of fast electric elevators which carry the material to the twelfth or twentieth story in as many seconds. The drilling of the holes for the plungers of some elevators is another curious problem. For every foot that the elevator rises in the completed building, a counter-weight plunger must go straight down into the ground. The hole into which this weight descends is usually about a foot in diameter, so that a hole of this size must be bored into the earth perhaps three or four hundred feet for each elevator. These holes are drilled with diamond drills which will pass through the hardest rock.

It might be possible to build sky-scrapers of stone or brick to the same height as the steel structures, but such buildings would be no safer, they would be vastly more expensive, and would take very much longer to put up. Then again the lower walls of a stone structure would have to be so very thick that there would be but little room left on the lower floors, or space for windows. The only question which remains is how long these buildings of steel will stand. The walls do not matter, for even if they should crack and fall away, they could readily be replaced, for it is the steel frame that carries the weight of the floors and their contents. And it chances that even this question has been answered, if at frightful cost, by the sky-scrapers which survived the great fire in Baltimore and the earthquake at San Francisco.

Built at a cost of more than $7,500,000

—

In style it is a combination of Italian and French Renaissance architecture, with Gothic steeples ornamenting the roof.

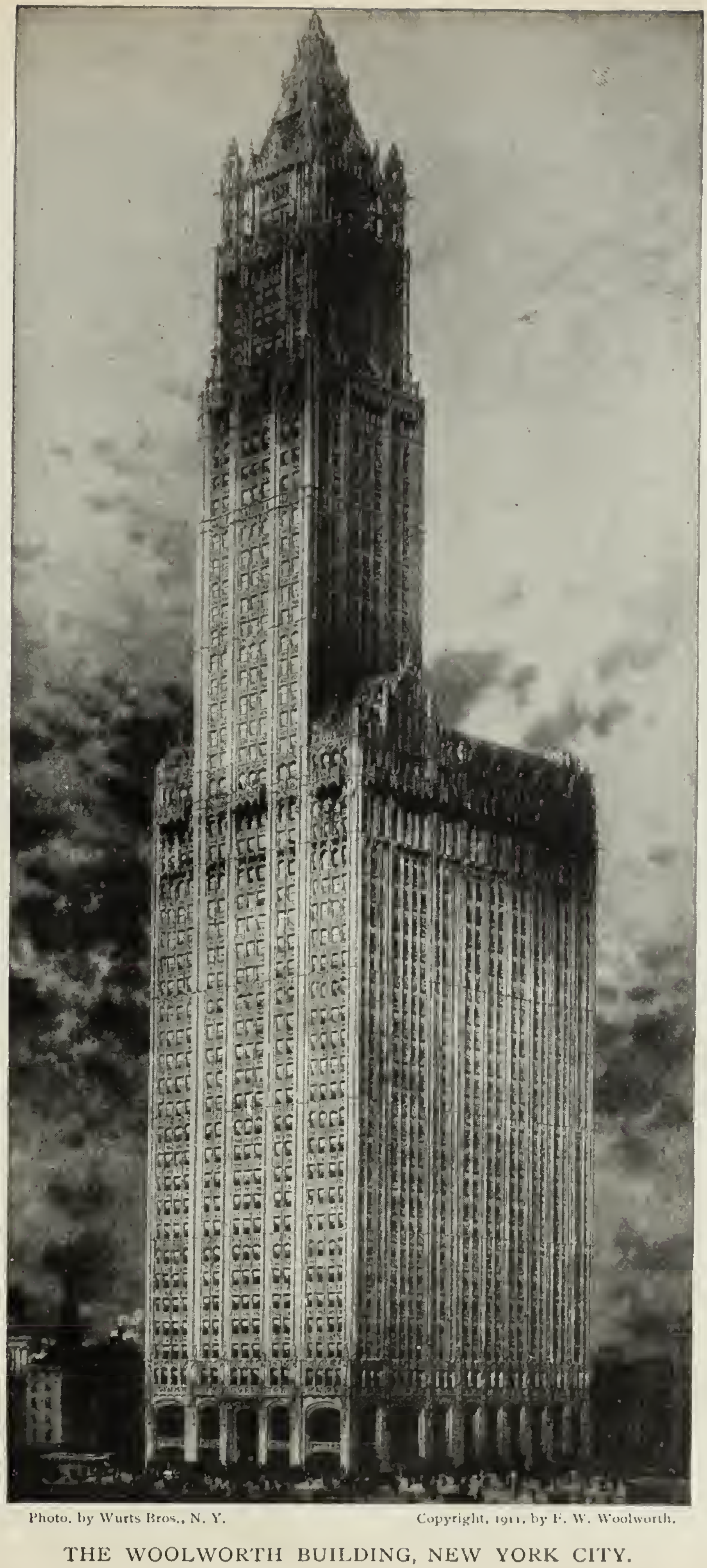


Photo. by Wurts Bros., N. Y. Copyright, 1911, by F. W. Woolworth.

THE WOOLWORTH BUILDING, NEW YORK CITY.

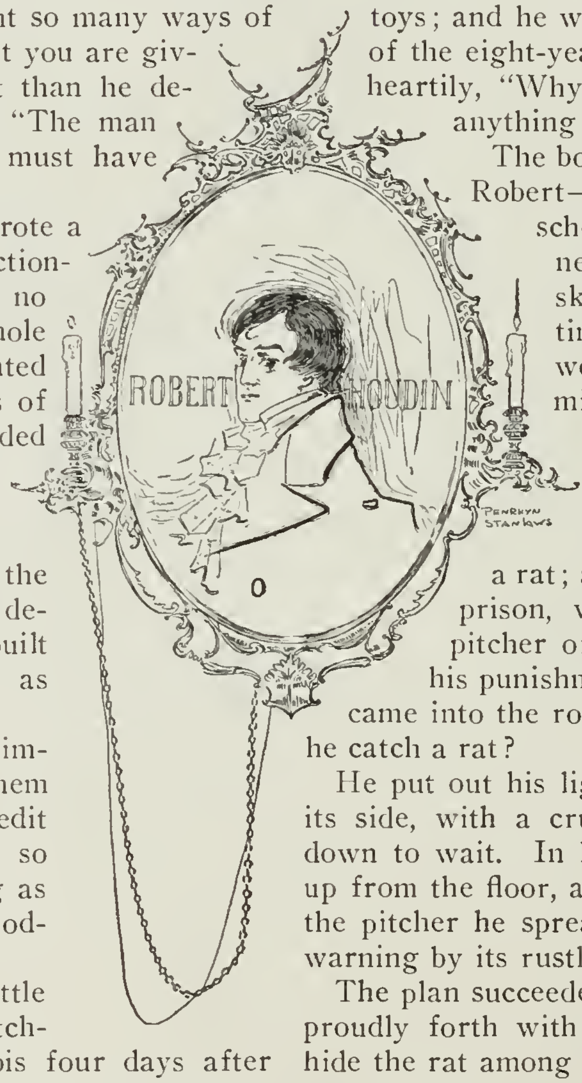
The tallest business structure in the world, 55 stories high, or 750 feet from the street level to the cupola. It is 300 feet taller than the Great Pyramid of Cheops.

TRICKS AND MAGIC

A MODERN MAGICIAN

BY TUDOR JENKS

WHEN you see a conjurer's wonderful tricks you are likely to wonder how he was clever enough to think of them all and to invent so many ways of mystifying his spectators. But you are giving the conjurer more credit than he deserves. It is as if one said, "The man who wrote the encyclopedia must have known everything!"



Just as no one man ever wrote a complete encyclopedia or dictionary "all out of his own head," no one man ever exhibited a whole entertainment of tricks invented by himself. Tricks and feats of skill in conjuring are handed down from one conjurer to another, and each new one learns from all the others.

Very probably some of the tricks still shown to-day once delighted the Egyptians who built the pyramids and now rest as mummies in our museums.

But some men so greatly improve upon what is taught them as to become entitled to the credit of originators; and one man so improved the art of conjuring as to be called "the father of modern magic."

This man was once a little French boy, the son of a watchmaker. He was born in Blois four days after Napoleon I. won the great battle of Austerlitz. During his boyhood he was attracted by his father's toolshop, and often had to be driven out of it. From a neighbor, an old army officer, the boy learned to make a number of mechanical toys and also invented new ones. This neighbor, Colonel Bernard, had been a prisoner for many years and had amused himself by making these little toys; and he was so pleased by the ingenuity of the eight-year-old boy that he used to say heartily, "Why, the young scamp can make anything he likes!"

The boy—his name was Jean Eugène Robert—loved toy-making better than school, and says that a long illness gave him leisure to try his skill. Even at school he found time to make a cage in which were contrivances worked by mice. One day he made a pump out of quills (his quill pens, no doubt), and found it could not be driven by mere mouse-power. He longed to catch a rat; and being shut up in the school prison, with only some bread and a pitcher of water, he was reconciled to his punishment by remembering that rats came into the room at night. But how should he catch a rat?

He put out his light, placed his pitcher flat on its side, with a crust of bread within, and sat down to wait. In his hand he held a brick dug up from the floor, and in front of the opening of the pitcher he spread out a bit of paper to give warning by its rustling when the rat entered.

The plan succeeded, and next morning he came proudly forth with his captive. But he had to hide the rat among his clothes, and as the clothes were gnawed the whole story had to be told to the head-master. A long lecture followed, and Robert promised to be good until he graduated—a promise he faithfully kept until he left school at eighteen.

During a short holiday, while wandering along

the Loire River, he witnessed the tricks of a traveling peddler, and eagerly bought a little book on conjuring, hoping to learn the mystic art. But he found the explanations harder to understand than the tricks themselves, and soon gave up these studies.

He became a copying clerk, but in his leisure preferred to copy exactly a mechanical snuff-box

THE MAGICIAN, HIS SON ÉMILE, AND THE CUSTOMS OFFICER.

that had been left in his father's shop to be mended. On its lid was shown a hare feeding; a hunter and dog appeared; click! the hunter shot at the hare, which ran away, pursued by the dog. When Robert had made the duplicate box, he showed it to his father; the father praised his skill, but strongly advised his son not to meddle with mechanics, but to learn a profession.

Sent into a lawyer's office, Robert was more interested in a cage of canary-birds that he found there than in his legal papers; and he made for the cage a number of moving tricks worked by the birds. At length the lawyer advised him to give up law and to follow his natural tastes, and persuaded Robert's father to apprentice the son to a watchmaker—much to Robert's delight.

Absorbed in his mechanical work, Robert was thinking little of conjuring when an odd accident turned his mind again in that direction. He went to buy a book on watch-making, and the busy bookseller did up by mistake two volumes about magical tricks—an error that was not discovered until Robert was at home.

As long as his candle burned the young man read his new books; and when, suddenly, the candle sputtered and went out, he was in despair. He tried in vain to sleep, but could not bear to leave the fascinating study. He rose, seized a pair of pincers, and, half dressed, went down to the street, meaning to "borrow" one of the lamps from the hanging lanterns that then lighted the streets. But just as he took it down, a baker came out of a shop and stood in his doorway smoking his pipe, while Robert was shivering behind a door-post not far away with the lamp hidden in his hat. At length the lamp set fire to Robert's hat, and had to be put out, and the young man at last returned to his room disappointed.

A week's study taught him all the books could impart, and then he learned he needed skill as well as knowledge. For ten francs a neighbor taught him to juggle with balls, and Robert at the end of a month could keep four going at once, and even read a book at the same time. He added other feats to this accomplishment, and practised constantly with cards, coins, and other little things—wearing a loose overcoat with big pockets so that he might practise while going about the streets. Having entered the service of another watchmaker in Tours, Robert gave amateur entertainments to his master's family.

Then, accidentally poisoned by a dish cooked

in a copper kettle, Robert feared he would die, and became so homesick that, before he was able to stand the journey, he started for Blois by stage. Becoming light-headed, he jumped out, and being unnoticed, was left in the road unconscious. He was picked up and cared for by a traveling magician named Torrini, who gave performances in a sort of gipsy-wagon that was built double and could be drawn out like a telescope, and thus formed a theater.

A STAGE MAGICIAN OF THE OLD STYLE.

For six months Robert went about with this kind old conjurer, learning his tricks and aiding in his performances. And when the gipsy-wagon was smashed in a collision, Robert gave entertainments until he could repay the old conjurer's kindness by setting him up in business once more.

It would take too long to tell all the history of the old magician,—you will read that some day for yourselves, perhaps, in the book Robert wrote about himself,—but among the tricks he performed was the "box trick," where a man goes into a box or basket, which is sawed in two or pierced by swords, and then appears elsewhere unhurt. At this time Robert performed the "omelet trick"—cooking eggs in a high hat. Once he burned the hat, and would have been disgraced except for a quick-witted assistant who substituted Robert's hat for the borrowed one, and put into the crown a note asking the spectator not to betray them, and promising a fine new hat next day. The secret was kept.

Robert, though fully determined now upon being a magician, returned for a while to watchmaking; but, while acting in some charades, he met a charming Mademoiselle Houdin,* and before long married her. Since his own name was a common one in France, Jean Eugène Robert took henceforth his wife's name in addition to his own, and he is known to the world as Robert-Houdin.

As his father-in-law was in a business connected with watchmaking in that city, Robert-Houdin went to Paris and assisted him, but kept alive his interest in conjuring by attending all the exhibitions that were given, and by frequenting the shop of an old man named Poujol, who sold magicians' apparatus; he thus learned many new tricks, and met the "professors of magic"—among others Jean de Rovere, who invented the word "prestidigitateur," meaning "one ready with the fingers."

Houdin (as we may now call him) learned in these days to dread the uneducated spectators more than those who knew more. He explains that the educated audience comes to be amused, while the uneducated spectators wish to prove their cleverness by seeing through the tricks of the performer.

Houdin also read all he could find upon the mechanical side of his preferred vocation, but he found little in books save fables and wonder stories. He studied all that was on record about the works of Jacques de Vaucanson—who had made a mechanical figure that played the trumpet, another that beat a tambourine, and a wonderful moving duck; and he was lucky enough to repair the duck, and thus found out just how its "wheels went round." But the most astonishing contrivance he found was the famous "Automaton Chess-player" that had once set all Europe to guessing.

Houdin explains this trick. The figure was a Turk, apparently too small to hold a man inside, and it played chess successfully against the best players in the world—being rarely beaten. But the whole contrivance was a mere deception. The figure was moved by a Polish officer, a refugee who had lost both legs in battle, and was therefore able to pack himself snugly into the hollow figure or into the chest upon which it sat.

* This French name is pronounced "oo-dan"—only in saying *dan* you suppress the *n* sound.

While the inside of the Turk's body was examined the officer was stowed in the box below; and he climbed up into the Turk when the box was inspected.

Thus hidden, the officer played chess against Catharine of Russia while that Empress was offering a reward for his capture. It is said the imperial player cheated, whereupon the mechanical Turk lost his mechanical temper and swept the chessmen from the board!

Afterward Catharine ordered the figure to be left in her palace, M. de Kempelen being thus forced to carry off the real player in a packing-box. The next day (probably after the Empress had tried in vain to discover the "missing link") Kempelen explained that the chess-player required his own personal attention, and thus persuaded her to let it go!

A circumstance that helped to fool the public was the fact that the Polish officer wore artificial legs while out of the figure.

This chess automaton was once owned by Napoleon Bonaparte, came twice to this country, and in 1854 was burned in Philadelphia.

Another marvel that came under Houdin's notice at this time was a mechanical musical orchestra—a gigantic music-box. Having rashly undertaken to repair it, it was delivered to him as a tangled mass of fragments of metal. For a whole year he worked upon it, and finally was entirely successful—but was soon after attacked by a brain-fever that caused him to pass five years almost in idleness.

When completely recovered, Houdin set to work again at mechanics, and made several moving figures of his own invention. With these and the tricks he already knew, he hoped to begin his career as an exhibitor and performer; but hardly had Houdin planned out his little theater when his father-in-law failed in business.

Houdin took to mending watches again, and for some time was poor; but the invention of a clever alarm-clock that brought out a lighted candle after ringing the waking-bell, and the sale of several automatic figures—a dancer, a juggler, and singing-birds—restored his fortunes until he could once more proceed with his plans for a theater of his own in which to exhibit the best pieces of work he had made and to present his magical performances.

One automaton that he specially wished to complete before his public performances now absorbed all his time and labor; but when it was finished, Houdin might well be satisfied. It was a figure that wrote answers to questions and could also make drawings. But he made it *too* perfect. It was noiseless, and the public thought it too simple to be wonderful. So Houdin let the wheels buzz a little,—to remind the spectators that it went by machinery,—and thereafter it was considered a marvel indeed. After this was done, he undertook to make a perfect imitation of a nightingale's song by clockwork; and after long study and hard work he was successful in this task also.

He sold these two contrivances for seven thousand francs—fourteen hundred dollars.

His writer, which Houdin named "Auriol," was borrowed from its buyer and exhibited in a Paris exposition in 1844. Louis Philippe, then King of the French, brought the Duchess of Orléans and her son, the Comte de Paris, to see

THE MAGICIAN AS HOUDIN PRESENTED HIM.

the little figure; and, in answer to the King's question as to the number of inhabitants of Paris, the figure traced with its pencil the figures 998,964 (about one third of its present population, by the way). The King said the new census would soon show more, and Houdin cleverly claimed that when the census came out his writer would probably be wiser—an answer that amused the King. Then, after Auriol had supplied a rhyming word to an incomplete verse, the little prince was asked to choose from some cards the name of an object for the automaton to draw. The little Comte de Paris chose a card, and found it

called for a crown—which was a pretty compliment the skilful conjurer brought about.

The automaton had nearly completed the drawing when its pencil broke. Houdin stepped forward to put in a new one, but the King good-naturedly said that the little prince could finish the drawing for himself as a lesson.

HOUDIN AND THE ARAB CHIEF IN ALGERIA.

This exhibition brought Houdin a silver medal, and also made him somewhat known to the public.

Houdin was at last able to build the little theater for which he had so long planned, and, when it was complete, he gave a "dress rehearsal" before a few friends. It was a hot June day, and in the middle of the performance, one by one, all his spectators fell asleep. Even the performer at last dozed also, and his pianist, thinking all was over, went out. This was the signal to the gas-man to put out the lights, and for two hours there was darkness and silence, except for a snore now and then.

Houdin, awaking, feared he had lost his sight; but his outcry aroused the friends, and, to their great amusement, all was soon explained.

His first public performance, July 7, 1845, was entirely successful; but the conjurer was so nervous that his heart failed him, so he took down his notices and resolved to abandon the ex-

periment. A "friend" called and assured him that he was very sensible to give it up—that he could never hope to succeed; and, stung by this cruel kindness, Houdin at once determined to go on at any risk. The advertisements were again posted, the performances resumed, and thenceforth his success was almost uninterrupted.

Among his tricks, none so much mystified the audience as what he called "second sight." He speaks in his book as if it were his own invention, and it may have been, in spite of its having been practised in a crude form some sixty years before by another performer. Certainly Houdin wonderfully improved it, and made it a spectacle all Paris talked of.

Houdin's son, Émile, with bandaged eyes, would clearly describe any article the audience handed to his father; and when the people found that whatever they brought—ancient coins, foreign books, queer tools, minerals—was quickly named and told about in detail, they saw that there were no accomplices, and considered the trick a marvel. Then the theater was crowded whenever opened.

Houdin needed quick eyes and a ready brain to solve the puzzles brought to him; for of course the son could tell only what the father reported to him by secret signals. One evening, for instance, a man suddenly covered the number on the back of the stall he sat in, and defied the conjurer's son to give the number. Houdin, at the moment, of course did not know, and he pretended to object; he said his son only saw through the father's eyes, and so, of course, could n't be expected to tell a number unknown to the conjurer himself. But while Houdin talked, and while the spectator was boasting to his friends that he had puzzled the famous magician, Houdin had made a rapid calculation, had found the number, and conveyed it to his son, who said, "It is No. 69," to the complete confusion of the "smart" man and the delight of the audience.

How did Houdin find out the number?

He says that he knew theaters were arranged with even numbers on one side, odd on the other. He counted ten seats in each row, twenty across the theater; commencing at the right with 1, the second row would begin with 21, the third with 41, and so on. His questioner was in the fourth row and had the fifth seat from the end; and beginning with 61 at the fourth row, he counted "61, 63, 65, 67, 69," and then announced the number correctly as 69.

By continual study, the conjurer and his son learned all about the strange things audiences selected to puzzle them, and it was a very outlandish object about which they were not better informed than the spectators themselves. Long lists of names and dates were committed to memory, and the boy Émile was also trained to remember whatever he saw, even in a single glance. Father and son would often walk rapidly past a shop-window, and then see which could write down the best list of what was within. Houdin says his son soon beat him at this game.

Going once to give an entertainment at a private house, they entered through a library. Houdin told Émile to notice the books in passing. The boy gave a rapid glance at the case. Later in the evening, the conjurer announced that his son could "read through the wall"; and asking for a book, Houdin was led out into the library. He at once called out to his son and asked the name of a book he touched. The name was given, and without further question the young second-sight performer gave the names also of volumes above, below, and on each side of the one touched, repeating a dozen titles. All these he had remembered from one glance.

It seemed witchcraft then, and seems hardly credible now; and yet there was in a New York paper not long ago an account of the examination of a class of young women who, after a short glance, told exactly what was written in sixty-four squares of a blackboard—though the board had been shown only a moment or two. *All* the girls had learned this art, and all of you can learn it by practice. But Houdin *discovered* that it could be done, and it is such discoveries that prove him a genius.

While making a foreign trip, Houdin was stopped at a custom-house, and would have been put to much trouble except for a clever trick that won him the favor of the customs officer. The officer asked for a specimen of his talents; and Houdin called to his son, who was playing not far from where the men stood.

"What do you see in this gentleman's pockets?"

"A blue-striped handkerchief," replied Émile.

"He might have seen that," said the astonished officer.

"What is under that?" inquired Houdin.

"A green spectacle-case," replied Émile, promptly.

"What next?"

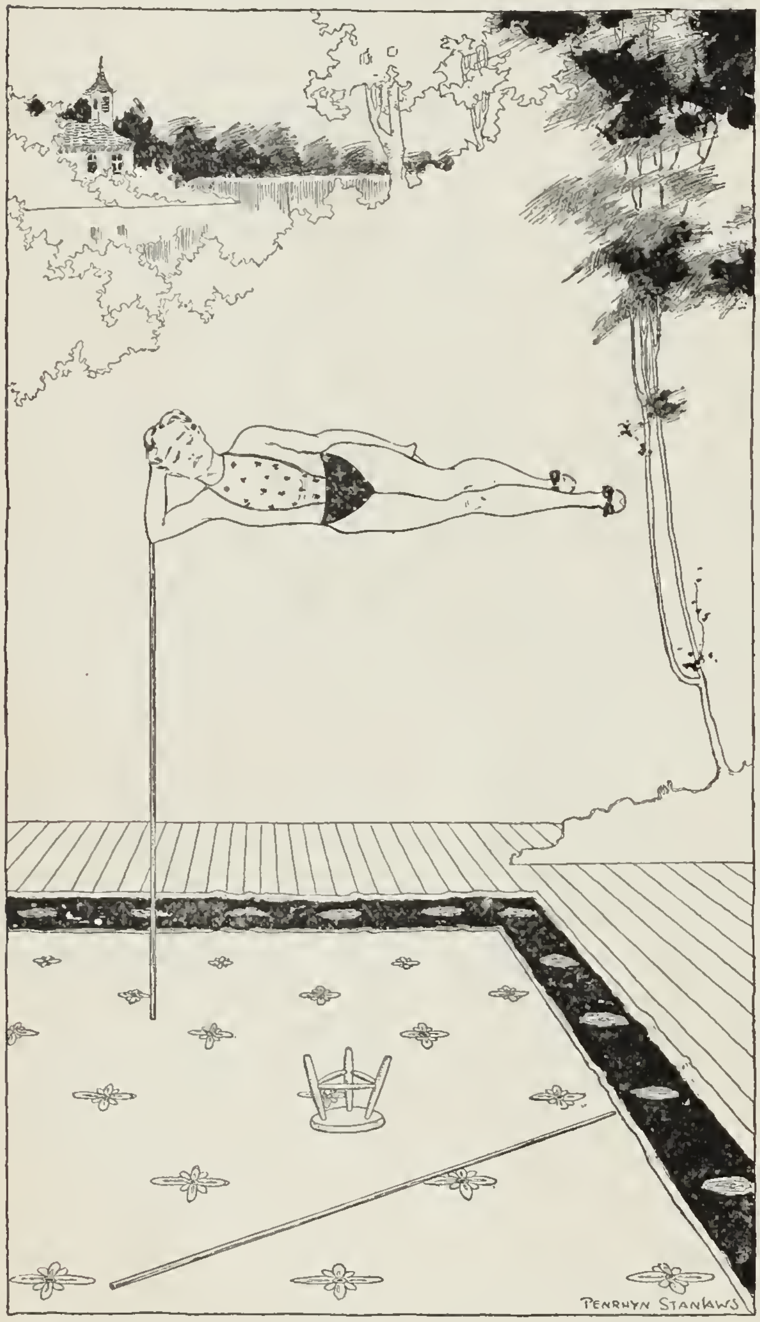
"A lump of sugar saved from his coffee."

This last answer convinced the officer that Houdin was a great conjurer, and he let the baggage pass. The trick was simple, however; for Houdin had slyly picked the man's pocket, and then replaced its contents.

The foreign trip was a failure, for Houdin was robbed by his manager, and he returned to Paris,

resuming his "Soirées Fantastiques," as he called them. These "fantastic evenings" were very different from what other conjurers then offered. While they wore queer robes covered with magical emblems, and filled the stage with heavily curtained and tasseled tables, Houdin was in simple evening dress, and had only a light stand, undraped. But in that light, flimsy table were hidden ten spring-rods moved by strings running down its slender legs and attached to a keyboard managed by a skilful assistant. These ten rods, pressing against the feet of different objects set on the stand, truly worked wonders.

In November, 1846, King Louis Philippe "commanded" Houdin to perform at St. Cloud, and the magician crowned a successful evening by a wonderful trick. He borrowed six handkerchiefs. Then those present wrote on cards where they chose to have the handkerchiefs appear. The King drew three. One suggested, "Under the candelabra on the mantel"; a second, "In the dome of the Invalides"; a third, "Inside the box of the last orange-tree in the avenue." Choosing the third, the King sent servants to guard the box. Houdin put the handkerchiefs under a glass bell, waved his little magic wand, and raised the bell. A white dove walked out.



"ETHEREAL SUSPENSION." ONE OF HOUDIN'S ILLUSIONS.

Then an attendant was sent by the King to open the box, and returned with a rusty old chest. The King asked whether the handkerchiefs were in the box, and Houdin assured him they were. The chest was unlocked with a key taken from the dove's neck, and out came a musty, fusty parchment certifying, under the seal of the noted Cagliostro (a well known magician of a hundred years before), that the six handkerchiefs had been put there in 1786 for the purpose of a trick to be performed by M. Robert-Houdin before Louis Philippe, etc.

Beneath the parchment was a packet sealed with Cagliostro's signet, and in the packet were the handkerchiefs!

The next year Houdin brought out another wonder; for he believed a magician could not afford to rest on past triumphs. At this time ether was much talked about, being a new discovery, and Houdin asserted that he had discovered a means of making a body float in the air—"ethereal suspension" he termed it.

He would lead his little son out upon the stage and mount him on a stool. Then a light cane was put under each elbow, and, with much hocus-pocus, the magician pretended to hold a bottle of ether to the child's nose. After a moment the magician moved out the stool, and the boy seemed to rest securely on the canes. A cane was taken away, and still the boy hung in the air. Then the child was lifted sideways until he seemed to recline gracefully upon nothing except the light cane under one elbow.

Like Columbus's (or Brunelleschi's) egg trick, it is easy when you are shown how. The light cane concealed a steel rod whose lower end entered a socket in the stage, and whose upper end fitted a light steel frame fitted to the boy's body under his stage costume, and thus held him securely.

It is believed that this trick was invented by the Chinese—but then, you know, they claim everything. The later magicians improved it by

seeming to remove even the last cane, which was done by making the polished steel bar within the cane triangular, so that it reflected the stage-curtains at the sides. As these were like the curtains behind the figure, the bar could not be seen.

But in 1848 a revolution in France drove out the King of the French, unsettled public affairs, and put an end to all theatrical business, including Houdin's. The conjurer went to England and gave many performances, appearing before Queen Victoria and Prince Albert, the Duke of Wellington, and Louis Napoleon—who was soon to become first the President and then the Emperor of France.

Going to Manchester, the manufacturers' operators came in crowds to the show; but when Houdin began to speak French they roared out: "Speak English!" and Houdin delighted them by good-naturedly doing his best in broken English, stopping every now and then to ask, "How do you call this?" when he was at a loss for a noun.

After fifteen performances Houdin had to give place to the great singer Jenny Lind, and he traveled about to different towns until summoned to give an entertainment before the Queen at Buckingham Palace.

In 1849 Houdin returned to Paris, and after three years he retired from the stage to give his time to electrical and scientific inventions. One suggestion he made has since been carried out—the sending of correct time by electricity, so that all clocks may be made to agree. The United States sends every day a signal when the official clock points to noon, and this has grown to be a most important service.

But the French government called upon the retired conjurer for one more appearance. It was when the French had conquered Algeria, and were trying to rule the country. Native "prophets" or magicians, known as Marabouts, were stirring up insurrections and exciting the Arabs by pretended miracles. Houdin was called to go to Algeria and to excel these native performers, so that the intelligent chiefs might see the false prophets outdone by a mere performer in theaters, and so that the ignorant Arabs might believe the French magician more powerful than their own.

Houdin consented, and gave a brilliant exhibition of his powers. How the Arabs stared to see cannon-balls and flowers lifted from an empty hat, an empty bowl filled mysteriously with smoking coffee, and money thrown across the theater into a closed glass box swinging from a long cord!

Then Houdin declared he could make the strongest Arab powerless in a moment. A brawny chief leaped upon the stage and defied him. Houdin pointed to a small metal box and told the Arab to lift it. It was lifted with ease, and the Arab sneered. Houdin waved his wand above the chief's head, telling him to try again. Pull and tug and strain as he might, the little box never budged; nor was this strange, for an electromagnet was holding it down. The Arab let go and paused for breath, and returned to the struggle with renewed strength. But as soon as the poor chief touched the box, he began to dance and yell and writhe; for the electric current had been connected with the handles.

Another Arab—a Marabout—leaps upon the stage, and says he will shoot the French magician. Houdin permits the Arab to load a pistol and fire it at him—and then shows the bullet in an apple he has held in his fingers. And after Houdin has put a big fellow on a table, covered him with a cone, and then caused him to disappear, the native audience waits for no more, but rushes panic-stricken to the door, only to meet the missing Arab from the cone.

A trip in Africa followed, then a stormy voyage to France, and Houdin's career as a public performer was at an end. He died in 1871.

Before the day of Robert-Houdin most professors of white magic were mere mountebanks; this Frenchman made the "prestidigitateur" a gentleman whose finer art was concealed by simplicity. In his performances there was no vulgarity, no cruelty, nothing debasing. He amused and delighted thousands, and was always an upright, honorable gentleman.

TWELVE TRICKS WORTH TRYING

HOW TO LIGHT A CANDLE WITHOUT TOUCHING IT

Having allowed a candle to burn till it has a long snuff, blow it out suddenly. A wreath of smoke will ascend into the air. Now if a lighted match is put to the smoke at a distance of three or four inches from the wick, the fire will run down the cloud, and relight the candle.

HOW TO BOIL WATER IN A PAPER BAG

"Here is a sheet of note-paper; can you boil me a little water in it?"

This would appear to be a thorough puzzler, yet it is exceedingly easy to do. Fold a piece of paper so that it will hold water, and suspend it above the flame of a lamp. The water will so readily take up all the heat that there is none left with which to burn the paper, and presently it will bubble and give off steam.

LIFTING A BOTTLE WITH A STRAW

It is quite easy to lift a bottle with a straw, although the straw seems so frail as to be incapable of supporting any considerable weight, as indeed it would be but for our method of placing it. We select a straw that is uninjured—that is, one that has not been bent or broken in any way—and, bending the thicker end of it, we insert it in the neck of the bottle so that the straw rests in the bottle as shown in the picture. The bend of the straw must be on the angle formed by the side and bottom of the bottle. If we then raise the straw gently and steadily, the bottle will be lifted and supported. A quite heavy bottle may be lifted in this very simple way.

A CURIOUS CANDLE

To perform this trick, get a piece of candle, and weight it by sticking a nail into the lower end.

The nail must be just heavy enough to bring the top end of the candle, when placed in a glass of water, level with the surface, without allowing the water to touch the wick.

If you now light the candle, it will burn down to the end, in spite of the fact that it is surrounded by water.

This appears at first sight to be very improbable, but you will see, on thinking it over, that it is quite possible; for although the burning of the candle seems to bring the wick nearer to the water, yet, on the other hand, as the candle burns it becomes lighter and rises gradually.

ODD OR EVEN; OR, THE MYSTERIOUS ADDITION

You take a handful of coins or counters, and invite another person to do the same, and to ascertain privately whether the number he has taken is odd or even. You request the company to observe that you have not asked him a single question, but that you are able, notwithstanding, to divine and counteract his most secret intentions, and that you will, in proof of this, yourself take a number of coins and add them to those he has taken, when, if his number was odd, the total shall be even; if his number was even, the total shall be odd. Requesting him to drop the coins he holds into a hat, held on high by one of the company, you drop in a certain number on your own account. He is now asked whether his number was odd or even; and, the coins being counted, the total number proves to be, as you stated, exactly the reverse. The experiment is tried again and again, with different numbers, but the result is the same.

The secret lies in the simple arithmetical fact that if you add an odd number to an even number the result will be *odd;* if you add an odd number to an odd number, the result will be *even.* You have only to take care, therefore, that the number you yourself add, whether large or small, shall always be odd.

THE BALL OF BERLIN WOOL

An easy and effective mode of terminating a money trick is to pass a marked coin into the center of a large ball of wool or worsted, the whole of which has to be unwound before the

coin can be reached. The explanation is absurdly simple when the secret is revealed. The only apparatus necessary except the wool (of which you must have enough for a good-sized ball) is a flat tin tube, three to four inches in length, and just large enough to allow a quarter to slip through it easily. You prepare for the trick by winding the wool on one end of the tube, in such manner that when the whole is wound in a ball, an inch or so of the tube may project from it. This you place in your pocket, or anywhere out of sight of the audience. You commence the trick by requesting some one to mark a quarter, which you must exchange for a substitute of your own, and leave the latter in the possession or in view of the spectators, while you retire to get your ball of wool, or simply take it from your pocket. Before producing it, you drop the genuine coin down the tube into the center of the ball, and withdraw the tube, giving the ball a squeeze to remove all trace of an opening. You then bring it forward, and place it in a tumbler, which you hand to a spectator to hold. Taking the substitute coin, you announce that you will make it pass invisibly into the very center of the ball of wool, which you accordingly pretend to do. You then request a second spectator to take the loose end of the wool, and to unwind the ball; when he has done this, the coin falls out into the tumbler.

THE CAPITAL Q

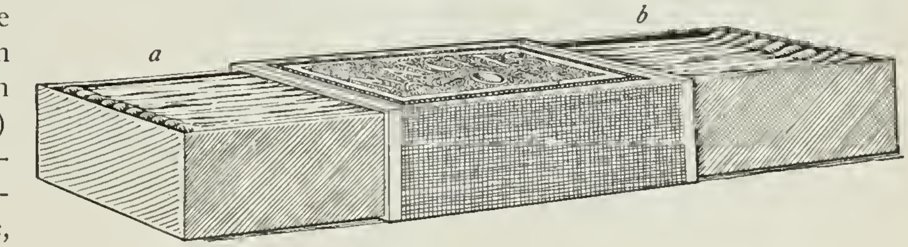
TAKE a number of coins or counters, say from twenty-five to thirty, and arrange them in the form of the letter Q, making the "tail" consist of some six or seven counters. Then invite some person (during your absence from the room) to count any number he pleases, beginning at the tip of the tail and traveling up the *left* side of the circle, touching each counter as he does so; then to work back again from the counter at which he stops (calling such counter *one*), this time, however, not returning down the tail, but continuing round the opposite side of the circle to the same number. During this process you retire, but on your return you indicate with unerring accuracy the counter at which he left off. In order to show (apparently) that the trick does not depend on any arithmetical principle, you reconstruct the Q, or invite the spectators to do so, with a different number of counters, but the result is the same.

The solution lies in the fact that the counter at which the spectator ends will necessarily be *at the same distance from the root of the tail as there are counters in the tail itself*. Thus, suppose that there are five counters in the tail, and that the spectator makes up his mind to count eleven. He commences from the tip of the tail, and counts up the left side of the circle. This brings him to the sixth counter beyond the tail. He then retrogrades, and calling that counter "one," counts eleven in the opposite direction. This necessarily brings him to the fifth counter from the tail on the opposite side, being the length of the tail over and above those counters which are common to both processes. If he chooses ten, twelve, or any other number, he will still, in counting back again, end at the same point.

The rearrangement of the counters, which is apparently only intended to make the trick more surprising, is really designed, by altering the length of the tail, to shift the position of the terminating counter. If the trick were performed two or three times in succession with the same number of counters in the tail, the spectators could hardly fail to observe that the *same* final counter was always indicated, and thereby to gain a clue to the secret. The number of counters in the circle itself is quite immaterial.

THE INEXHAUSTIBLE MATCHBOX

THE "matchbox" trick is as follows: An ordinary "safety" matchbox of small size, after being shown full, is completely emptied, the matches being turned out upon the table-cloth. The box



THE MAGIC MATCHBOX THAT ANY BOY MAY MAKE.

is closed. When again opened, it is found to be full of matches, as at first. These also are turned out. Once more the box is closed, and once more, when opened, it is found to be full. The third batch of matches is shaken out, after which the operator endeavors to put them all back again, but without success, for, even when packed as closely as possible, the box cannot be made to accommodate more than half of those on the table.

The secret lies mainly in the fact that the matchbox used, though ordinary in kind, has undergone a special preparation, as follows:

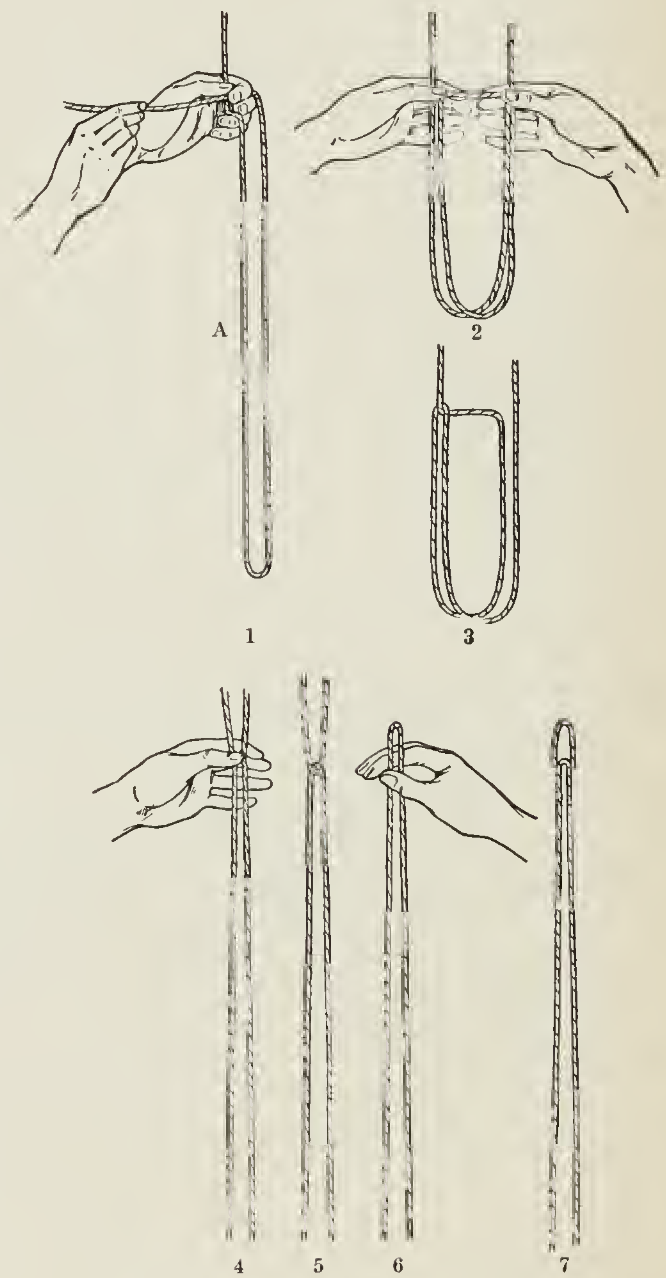
With a sharp penknife, split six or seven of the matches down the middle. Take out the "drawer" portion of the box, turn it over, and smear the under side with glue; then lay the half-matches, all pointing the same way, side by side upon it. If this is neatly done, the inverted drawer thus treated will have all the appearance of a full one right side up. When the glue is dry, reverse the drawer again, replacing the matches that it contained. Push it halfway only into the outer case; and into the opposite end of the same case push the drawer portion, also full, of another box. You will thus have two drawers in one case, the appearance being as shown in the picture. The unprepared drawer is represented by *a;* the prepared one by *b.* This box, at a suitable moment, the owner brings forward as if it were one in ordinary use, taking care to keep the end *b* well covered by his right hand. Making some remark about the strange properties of matches of this brand, he offers to give an illustration of one of them. So saying, he shakes out the visible matches upon the table, and shows the box empty. Remarking, "Now I will just close the box again," he brings the left hand up to it, as if merely to push in the drawer, but, as a matter of fact, presses in *b* from the opposite end, thereby pushing out the empty drawer into his left hand, where it remains concealed. He holds up the box in the right hand, showing it fairly closed.

This calls all eyes to the box, and gives him an opportunity to drop the empty drawer into his lap or behind a book or other convenient object placed beforehand on the table. Then, blowing upon the box, and pronouncing some magical formula, he pushes open the box again, showing that it is still full of matches. This is done with the one hand only, the other falling carelessly on the matches already turned out on the table, and secretly getting possession of a score or so of them, which he holds against the palm by the pressure of the thumb. The second lot of matches is now shaken out upon the first, and again the box is closed. Once more the performer blows upon it, and, under cover of so doing, turns it upside down. When he again opens it, it is once more apparently full, the matches glued to the bottom of the drawer being now brought into view. Transferring it to the opposite hand, he gives it a shake, allowing the matches concealed in that hand to fall from it as if out of the box, then again turning it, so as to bring the empty side of the drawer uppermost.

"Now," he says, "you can all testify that these matches came out of this box. To show you that there is no deception, and that they have really multiplied, we will try how many we can put back again." He fills the box, but there is still an equal number left over. These he presents to the company.

CUTTING THE MAGIC STRING

This is an old trick, but it is a very good one, and, improved to the form we are about to describe, it is very little known. It can be performed just as well by a girl as by a boy, and it has the great advantage of requiring no previous preparation. When we have once acquired the necessary skill, we can perform it at a moment's



THE TRICK OF THE MAGIC STRING.

notice, all that we need being a pair of scissors and a piece of string.

The string should be about four feet long. We begin by taking one end of it in each hand be-

tween finger and thumb, the rest of the string hanging down between them. But the end in the left hand is not held quite in the same way as the other, though no one not in the secret would notice any difference. If we look at picture 1 we shall see that the string passes out between the second and third fingers, and hangs down outside of the third and fourth ones.

Our next step is to bring that part of the string which is held in the right hand between the first and second fingers of the left, as shown in the picture, and draw it toward ourselves till half its length has passed through the fingers. Then with the right hand, still retaining the end we hold, we make a "grab" at the left-hand string at the point marked A, and bring it up so as to lie level between the hands, as shown in picture 2. To any one looking on, it seems as if you had merely gathered up the string in a double loop, but it is really as shown in picture 3.

Holding the string as above described, we ask some one to take a pair of scissors and cut it in halves, the portion between the hands appearing to be the middle, and he cuts at that point accordingly. When he has done so, we let go the string with the right hand, and let it hang down from the left, as shown in picture 4. Everybody imagines that it is fairly cut in half, but the real state of things is shown in picture 5.

Our next step is to transfer the string to the right hand, not disturbing its arrangement, but taking hold of it a little higher up, so that the upper ends, as well as the point where the two pieces of string cross each other, shall be hidden by the fingers. Asking some one to take hold of one of the long ends, we wind the rest of the string round our own left hand. This draws off the loose bit into the other hand, and when we again unwind the string it is found to be all in one piece, as at first. The little bit remains concealed in the right hand.

But we have not yet finished. Somebody—some uncomfortable person who knows, or thinks he knows, everything—may say, "Oh, yes; I know how *that 's* done. The string was n't really cut in half. You only had a bit cut off one end." "Oh, you think so?" we retort. "Then I will do it over again, and this time you may measure the string before and afterward." If nobody makes such a remark, we volunteer of our own accord to do this. While the string is being measured, we secretly double the bit that remained in the right hand, with the "loop" end upward, keeping it concealed between the fingers and thumb. When the string is handed back after having been measured, we double this also in half, and, taking it by the middle between the right-hand fingers and thumb, draw up for an inch or so what is apparently the loop thus formed, but is in reality the little loop made of the short bit. Picture 6 shows how the string now looks, and picture 7 the real state of things. We let some one cut through the loop, and wind the string round the left hand as before. It is again found restored, and when measured will, of course, be found to have lost none of its length.

This is not an easy trick to describe clearly in print, but if you follow the instructions with the string in your hands, and study the pictures, you will soon learn it. And it is worth learning, for it is a genuine sleight-of-hand trick, and such tricks are most mystifying.

SIMPLE TRICKS FOR ODD MOMENTS

There are many simple tricks performed with little or no apparatus that cause a great deal of amusement at any gathering of friends.

For instance, we announce that we can place a glass of water on the table, cover it with a hat, and then drink the water without removing the hat. This seems an impossible task, and every one is anxious to see the trick performed.

It is done in this way: We stand a glass of water on any ordinary table, borrow a hat, and place it over the glass. While doing this we talk and emphasize the wonder of the trick we propose to show our audience, and say that on no account must any one touch the hat.

Then we go under the table and make a pretense of drinking the water through the wooden table. Every one is, of course, skeptical, and after coming from under the table we ask one of the audience to remove the hat to see if the water has been drunk or not. As soon as this is done, we seize the glass and drink the water, and then announce to our surprised audience that we have done what we promised to do—namely, to drink the water without removing the hat, some one else having removed the hat for us!

Another simple trick is to take two cents from our pocket, and then ask if any one in the audience will lend us a cent. Of course, some one immediately does so, and we now have three cents. Placing the coins on the table, one after the other, we count them as we do so, saying:

"One, two, three—that makes four cents."

"No, three cents," says the one who lent the cent.

"One, two, three—that makes four cents," we repeat, as we count out the three cents again, and regard our friend with a surprised look.

Our friend insists once again that we have three only, and then we exclaim:

"Well, can I keep the cent if I am wrong?"

In nine cases out of ten the answer will undoubtedly be "Yes."

"Well, I *am* wrong, so I keep the cent," we reply, and our friend then realizes that he has been tricked, while the audience laughs heartily. We should practise this before trying it at a party, for the success of the trick depends upon there being no hesitation in the counting.

There is another simple trick that usually mystifies an audience and creates much interest. We undertake to pick a marked coin out of a hat without seeing it. First of all we borrow a hat, and then ask three or four members of the audience to put a cent each into the hat. We next cover this with a pocket-handkerchief, and talk for a minute or two to allow the coins to get cool.

Now we ask any member of the audience to take one of the coins from the hat and put a mark upon it, after which he is to return it to the hat and cover the whole with the handkerchief again.

Then comes the climax of the trick. Approaching the hat without looking at it, we talk of the wonders of magnetism, and, putting our hand under the handkerchief into the hat, extract the marked coin, to the astonishment of all beholders.

The explanation is as follows: In marking the coin, the member of the audience handled it for some few seconds, and the heat of his hand was communicated to it. When we feel the coins in the hat, the warmth of the one that has been handled is quite perceptible, and we are able to identify and to bring it triumphantly from the hat.

To be still more certain that the coin selected and marked shall be warm, we can ask the one who marked it to hand it round among the other members of the audience, so that they may all examine it thoroughly and be able to recognize it again when they see it. This adds to the importance of the trick and creates greater interest, besides insuring success.

THE CONJURER'S LITTLE JOKE

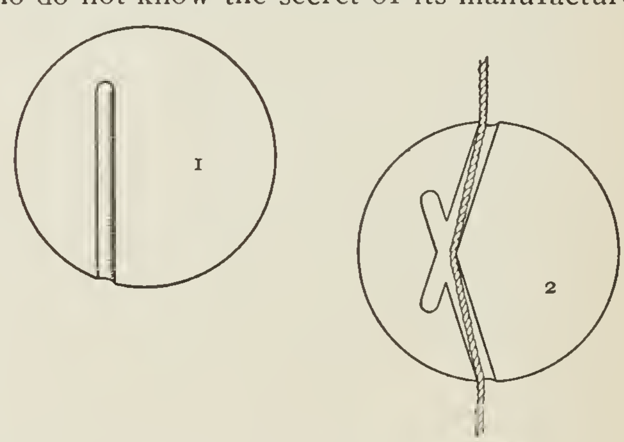
At the end of a series of tricks it is often a source of great amusement to entertain the audience with what school-boys call a "sell"—a practical joke in the disguise of a conjuring trick. The only apparatus needful is the pencil, and this you can manufacture for yourself. You have merely to change an ordinary pencil in such a way as to make it look like an extraordinary one. For instance, you may paint it in three colors—red, blue, and yellow, successive rings of each color; or, for lack of paint, colored paper may be used—anything, in fact, to give it an unusual appearance.

Having performed a few genuine tricks, you produce the pencil and a blank sheet of paper, inviting the company to examine them. "Now, ladies and gentlemen," you remark, "you notice, no doubt, that this is a rather peculiar-looking pencil. But its appearance is the least of its peculiarities. In point of fact, it is an electric pencil. At present, you see, it writes plain black like any other pencil." Here you make a few marks with it and proceed: "But if I electrify it a little, it will write red, blue, or yellow—in fact, any color, just as I please. What color will you have? Choose for yourselves." "Red," we will suppose, is the reply. You gravely breathe upon the pencil, rub it upon your coat-sleeve, and proceed to write the word "Red" in bold letters. "There it is, you see—red. If you had asked for blue or yellow, it would have been just the same." Which nobody can deny.

The success of the trick rests on the fact that the audience have been prepared, by seeing sundry surprising things, to expect something else equally surprising. If the trick were offered offhand, without such preparation, some of the audience would probably see through the joke; but if it is led up to in a proper manner, they will hardly ever do so.

THE BALL THAT ANSWERS QUESTIONS

One of the most interesting toys is a ball that seems to count and answer questions. To people who do not know the secret of its manufacture it

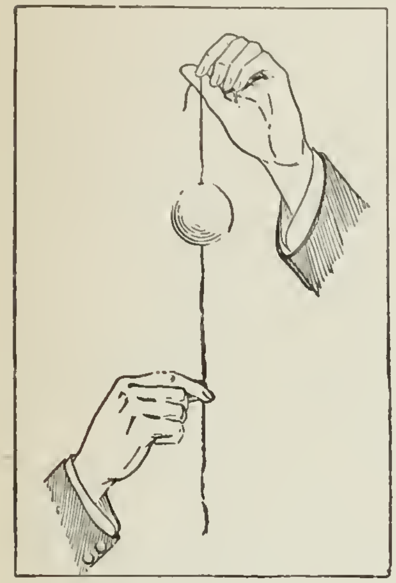


HOW TO MAKE THE HOLE THROUGH THE MAGIC BALL.

is very mysterious; and any boy can derive much amusement by making one, and showing it to his friends after he has practised with it a few times and become expert in its use.

Take a wooden ball about three inches in diameter, and mark upon the outside two points,

exactly opposite each other. In most wooden balls we find two center-points, that the wood-turner has used when making the ball. Then we use a gimlet, and make a hole in the ball, but *not* in a straight line toward the other point. The first illustration (1) shows how the hole is made; it is not through the center of the ball, but to one side. The hole is not made to go right through the ball, but it must go more than halfway.



3. HOLDING THE BALL.

Now we bore another hole from the opposite point. This is the only difficult part, for the second slanting hole must be made so that it goes right into the first hole, and the result is that we have a continuous hole right through the ball, but not in a straight line. The next picture (2) shows how the hole should be made, going through the ball, but not in a straight line.

Now we put a string through the hole from side to side, and after doing so we had better put a button on each end of the string, to prevent it from slipping out of the hole. Now, if we hold up the ball as the boy in the next picture (3) is doing, pulling the string tightly as we do so, we find that the ball remains fast at any part of the string we like. Let the string loose just a little, and the ball begins to slip down. Again tighten the string and again the ball rests.

Now we can ask the ball questions. Hold the string tightly with the ball at top of it. "Ball, how many do two and three make?" we ask; and, for reply, the ball takes five short steps down the string. Of course we are making it do so, by making it tight and loose as we wish. Then we say: "Ball, I am going to ask you some questions. If you mean yes, move once; if you mean no, move twice." We can ask any questions we like, and the ball can always answer them if we are allowed to hold it up by the string. A little practice will enable us to move the ball without any one detecting how we do it.

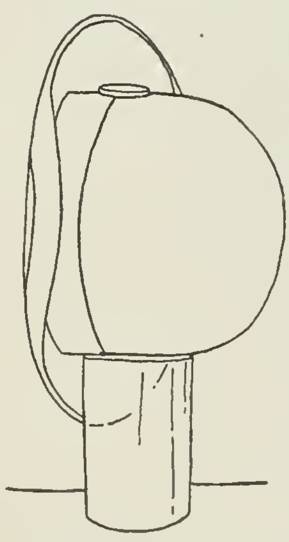
TRUZZLES

BY NORMAN D. GRAY

Tricks and puzzles are always in order during winter's indoor hours, but it is hard to find anything new. Here are a few little feats that may have the charm of novelty for many boys and girls. The experiments are neither tricks nor puzzles in the full sense, though they combine something of each. Our old friend Lewis Carroll would no doubt have arrived at "truzzles" through trying to say both words at once. One might do worse than to follow his example. All may be done with cents, or, if you will persist in so calling them, "pennies."

"In the first experiment on our program, ladies and gentlemen, we employ a copper cent, an ordinary glass tumbler, and a very ordinary derby hat." The poor quality of the last-named article must be insisted upon, as it is to receive hard usage. Place the hat over the tumbler, and the cent upon the hat, as in the picture. The trick, or the puzzle, or the truzzle now is to strike the hat from under the cent with a smart blow of the hand, allowing the coin to drop into the tumbler. It seems to be easy, but skip the next paragraph until you have tried it.

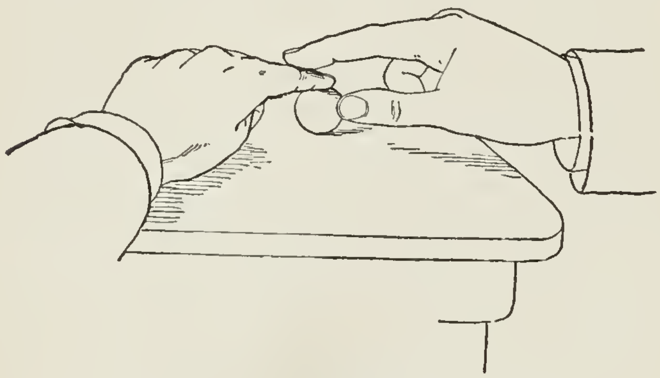
To do this successfully, which with practice may be done before an audience without discovery, place the hat between yourself and the company, with the crown away from you. Make several feints as though about to strike the outside of the brim on your right (if you are right-handed); but when the final quick blow is delivered, the inside of the brim on your left is the place to be hit. If this little trick is neatly performed, the audience will believe the outside of the hat to have been struck, and the copper will fall nicely into the tumbler. The spectator may puz-



THE COIN AND TUMBLER.

zle his brain for some time before he can solve and successfully perform this truzzle.

A second truzzle, very mysterious, is the magic spinning of a coin without evident impact. This sounds impossible, and really appears to be so



THE SPINNER.

when seen. The coin is held on edge by the first finger of the left hand, in the ordinary position for a snap spin. The right forefinger is now laid across the left, and passed repeatedly from knuckle to tip—"to produce magnetism," you may say to the onlookers,—and finally swept quickly off the end of the finger, apparently without touching the coin. The latter, however, bounds merrily to the middle of the table, and there spins contentedly, as if of its own accord.

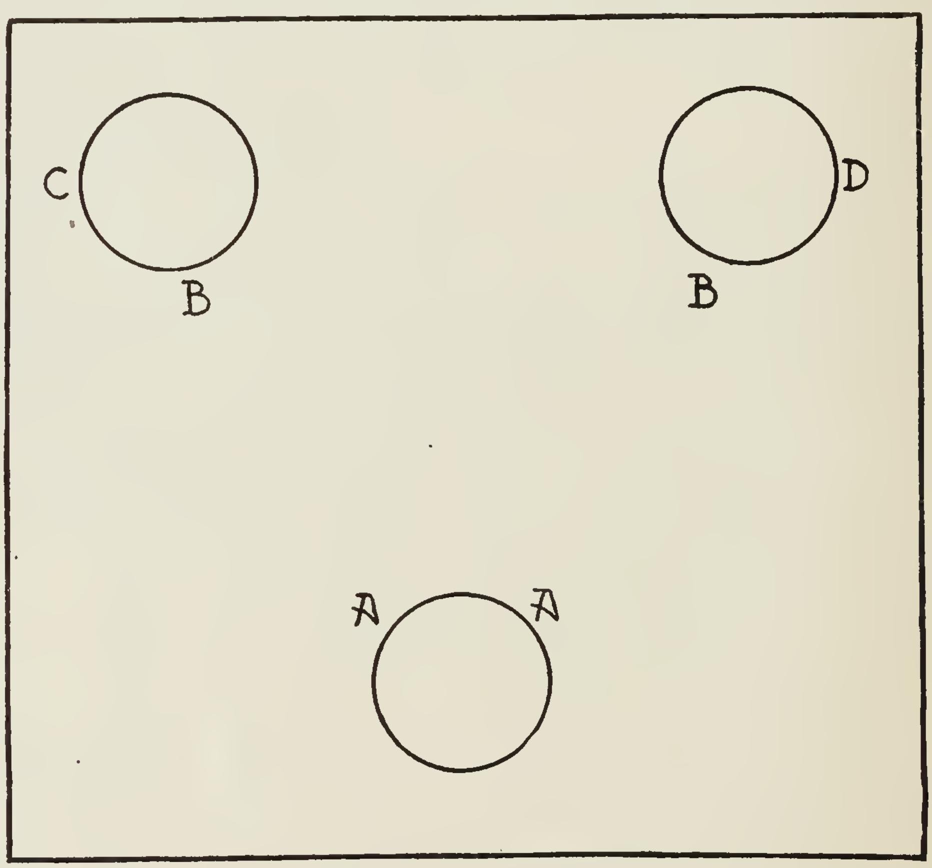
The accompanying illustration will make the trick of this truzzle clear. When the final stroke is given with the right finger, the thumb assumes the position shown, and is allowed to strike the edge of the coin, unseen by the spectators, and thus set it spinning.

While dealing with single coins, there is another clever puzzle which must be included, even at the risk of straining a point to raise it to the dignity of a truzzle —though, on second thought, there is something of the trick about it, after all. Cut a circular hole, about nine sixteenths of an inch in diameter, in a sheet of writing-paper. Through this opening, without tearing or cutting the paper in any way, a cent may be readily passed (when one knows how), although the diameter of the coin is considerably greater than that of the hole.

Place the cent over the hole, and fold the paper without creasing, so that the coin is in a kind of pocket, and partly projecting edgewise through the opening. Grasp the paper firmly, so that it cannot slip, and bend it slowly along the edges of the coin, though not forcibly enough to tear the paper, lengthening the diameter of the hole in the direction of the fold until it will allow the coin to drop quietly through upon the table. This result is surprising even to the operator, and furnishes a very interesting question for discussion. How is it possible for a solid coin to pass through an opening very much smaller than itself, and that without actually enlarging the aperture one iota? Who can answer it?

But here is something over which you need not bother your brains to such an extent. What would you think of being asked to drive a needle completely through a copper coin? Impossible? Well, it does seem so, and yet it may be done without hurting the needle in the least.

As for the method: First you select a cork a trifle shorter than the needle you mean to use. Push the needle through this cork until its point just appears at the other end, and break off the needle below the eye flush with the cork; then, holding "the business end" of the cork firmly against the coin, which must rest upon or against



THE COINS IN A TRIANGLE.

a rigid surface, strike it a fairly hard blow with a hammer. Examine the result, and profit by what you see.

Having now tested the brain and hand, sup-

pose an eye-test be attempted. Here is a form of optical delusion which shows how very difficult it is to measure distances accurately with the eye when there is the slightest thing to confuse the judgment. The following test is neither a trick nor a puzzle, and so naturally must fall in the third division, and take rank under the head of the present article. Place two coppers, a few inches apart, on a clean sheet of paper. The truzzle is to place a third copper below these, as in the diagram (judging entirely by the eye), so that the inside measurement, AB, shall be exactly equal to the outside measurement, CD. Draw a circle where the coin has rested, and mark it with your initials. Others may then try, and it will be interesting to compare results.

You will notice that the coin is invariably placed much nearer to the others than it should be, unless, of course, the tendency to error is known beforehand. One may attain some accuracy in the following way: imagine the coin resting on the paper so that the inside distances are equal, and then judge the width of two coins from the farther edge of the one you have imagined to be placed. The point thus obtained, provided that your eye is "good," will be found to coincide very nearly with the true one.

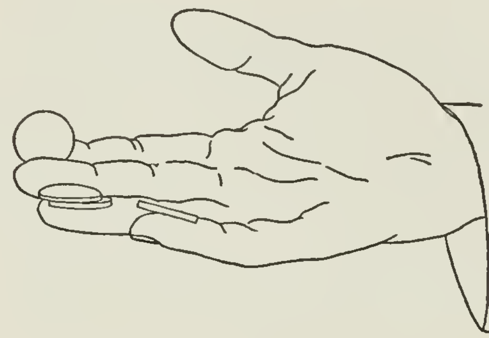
Put two coins side by side upon the table so that they touch each other, and take a third one in hand. The first you may touch, but not move; the second you may move but not touch; the third you may both touch and move. The object is to place the third coin between the other two.

Place your finger upon the first coin, and hold it tightly. Snap the third against this one, when the second, which was to be moved but not touched, will bound away far enough to leave room between itself and number one, which was to be touched but not moved, for coin number three.

Before leaving the subject of truzzles with coins, there should be mentioned three feats of skill in manipulation which furnish opportunity for practice in spare time. The first is an old trick, or knack, but must be new to some of you. Bend the arm, with the hand palm upward, over the shoulder until the forearm is horizontal. Place a coin upon the elbow and make a quick snatch at it with the same hand. It is a surprise to find it securely held in the fist.

With practice, a pile of coins may be caught in this way as easily as one, the whole secret being to treat them exactly as though they rested in the air, and to give no thought whatever to the arm on which they rest.

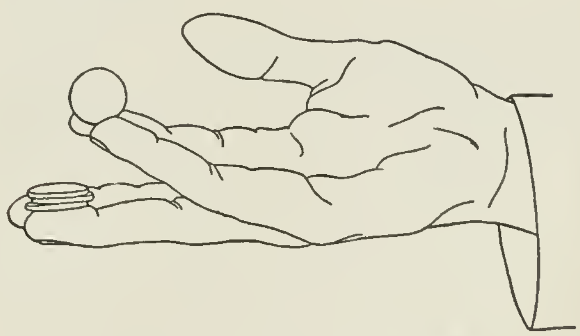
The second truzzle of pure skill is more difficult to attain than the first, and, therefore, one experiences a proportionately greater satisfaction when able to perform it neatly. Place four coins on the back of the hand, letting the last rest on the wrist. Now toss them upward, being careful that they preserve their relative positions, and, with the same hand, catch them, in quick succession, before they can fall to the floor.



TRAVELING COINS. FIRST MOVEMENT.

This is by no means easy to accomplish, and had best be practised first with two coins, and then with three, before attempting four. The secret of the knack is in the toss and *start*. Give them a steady, sweeping throw, not a jerky one, and (here is the important point) start to catch them—securing at least the first coin—before they begin to fall. Keep cool, have patience, and success will follow.

And now for the last and best of all—the finger truzzle with four "pennies." It had nearly been called "the four-cent finger truzzle," but there is a certain suggestion of cheapness about that phrase entirely unworthy of the feat. With the palm of the hand up, place a cent upon the tip of each of the four fingers, and without the use of the thumb, or of the other hand, without any aid whatever other than the fingers, pile all four coins upon the tip of the third finger of the same hand. It would be hard to find a more perfect example of the true truzzle. First, one must



TRAVELING COINS. LAST MOVEMENT.

discover how to do it (for it can probably be done in only one way), and, secondly, one must acquire the necessary deftness or skill for its accomplishment.

It is a pity if the illustrations have silently given you too broad a hint before you have had a chance to try this truzzle for yourselves. However, knowledge of the method is but half the battle won. The pictures will explain themselves. The first move is from the second finger to the third, the coin being slipped over with the assistance of the forefinger. The coin from the first finger must now be tilted on to the second (as in Fig. 1), to be then slipped to the third finger in the same way that coin number one was moved. The third coin is the most difficult to maneuver. Tilt it from the little finger to the forefinger (as in Fig. 2), after which it follows the course of coin number two. In general, it will be found conducive to success to hold the hand low, keeping the forearm nearly horizontal, and to have no support for the elbow. Practice will enable one to perform this feat with much apparent ease and dexterity. It is very effective, and more than pays a bright boy or girl for the trouble of learning it.

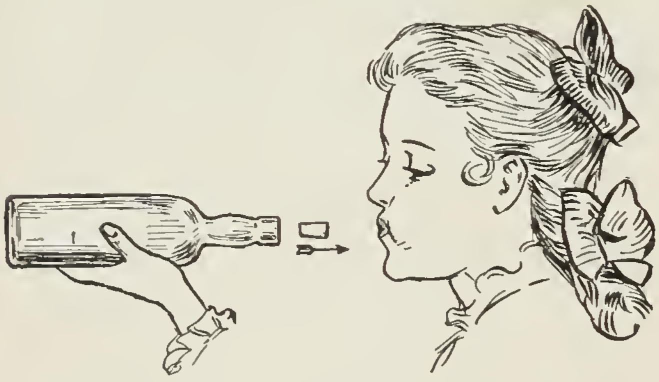
With this the coin truzzles shall be brought to a close. These will doubtless suggest others to the bright members of the party, and so the hours will pass by like the silent ghost of an express train, as hours have a knack of doing when one is busily employed.

TRICKS THAT ANY ONE MAY TRY

BY BORIS GLAVE

THE OBSTINATE CORK

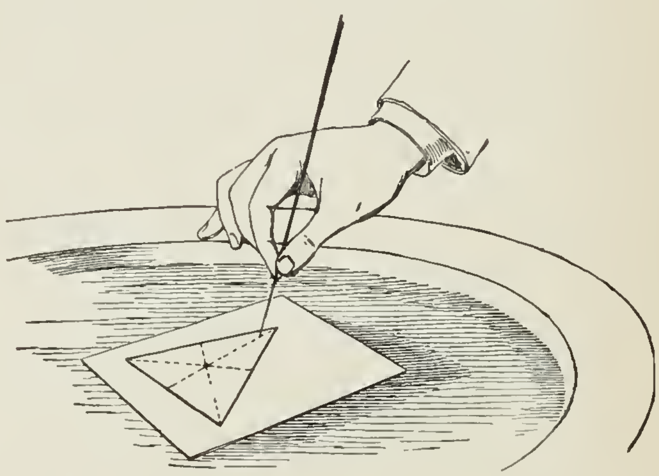
When I was a boy we had a song about "Aunt Jemima's Plaster," the peculiarity of which was that "the more you tried to get it off, the more it stuck the faster." Here we have a picture of an experiment with an obstinate cork that flies in the face of any one who tries to compel it to go into the neck of a bottle. The more you try to blow it in, the more it leaves the bottle. You can try this with any large bottle and a cork small enough to fit very loosely in its neck. Holding the bottle so that it points directly at your mouth, and placing the cork in the neck, the harder you blow on the cork for the purpose of driving it



into the bottle, the more forcibly will the cork rush from its place in the neck. Instead of a cork, the experiment may be successfully tried with a small ball of pith, or with one of paper.

THE MAGIC TRIANGLE

A very interesting experiment may be performed as follows: with a *wet* lead-pencil point draw on a piece of thick paper a triangle—whether the sides are equal or not makes no difference. Lay



it on the surface of a basin of water with the drawing up, and very carefully fill the space inside the dampened lines with water, so that there will be a triangular basin of water on the swimming sheet of paper. (The water will not extend beyond the wet lines of the drawing.) Now, taking a pin or a needle, or any thin, smooth, sharp-pointed instrument, dip its point into this triangular basin, anywhere but at its center of area—say, very nearly at one of the angles. Be careful not to touch the paper and so prevent its free motion in any direction, and you will find that no matter where the point is placed, the paper will move on the water until the center of area comes under the point. This center of area may be indicated before placing the paper on the water by drawing lines from any two angles to the centers of the opposite sides; where the two lines cross will be the desired place.

If a square be drawn instead of a triangle, and similarly treated, it will move until the intersection of its diagonals comes under the pin-point; and no matter what figure be drawn, it will move along the water so as to bring its center of area directly under the point.

THE POWER OF A BREATH

In order to show what force, not figuratively, but actually, a breath has, take a good, stout, tight paper bag, and laying it on the edge of a table so that its mouth projects, stand a heavy book on end on the bag, and across this book lay another, also of considerable weight. By blowing

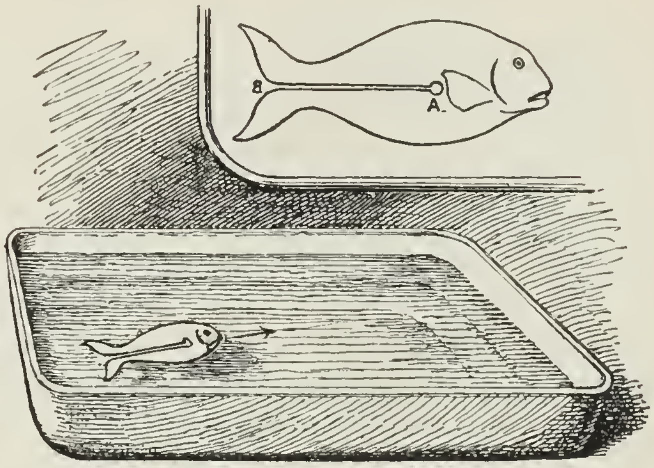
in the bag, keeping the mouth tight in the bag so that no air can escape, the upright book will be tilted and raised and the structure overthrown. It would, of course, be impossible to blow the book over without the aid of the bag.

THE PAPER FISH

Cut a fish out of stout writing-paper, and in the center cut a round hole, as shown at A in the figure; then from this cut out a narrow strip reaching to the tail.

Placing this paper fish in any long vessel full of water, it will, when you are ready for it to do so, slowly move head first along the surface of the water without your touching it. (Care must be taken to lay it gently on the water, so as not to wet the upper surface of the paper.) The fish, of course, lies *flat* on the water.

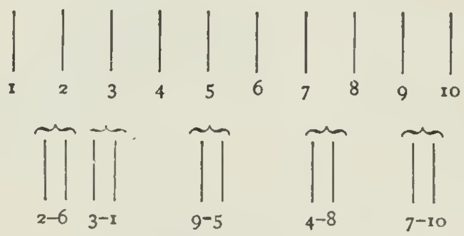
The secret lies, not in blowing the fish along, as some promptly guess, but in placing in the opening A a large drop of oil. This tries to expand and extend over the surface of the water; the paper is not porous enough to absorb it



promptly, so the oil seeks the path of least resistance. In this case this is found to be by passing out of the channel which leads from the hole A to B; and in issuing from this channel it will push the fish forward.

A JUMPING TRICK

Lay ten toothpicks in a row at equal distances. Move them by "jumping," as in checkers, so that two shall be "jumped" each time, and at last five pairs remain.

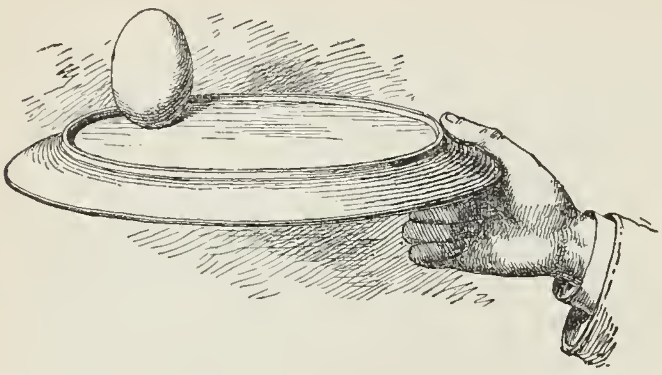


Solution: Lay 7 on 10, 4 on 8, 6 on 2, 1 on 3, 9 on 5.

THE DANCING EGG

To make an egg dance on the bottom of a plate, first boil it hard; then set it on its large end in the center of the plate, and, holding the latter horizontal, give it a rotation in a horizontal plane; the egg will keep spinning like a top. With practice, the egg may be made to assume the vertical position after being laid on its side. To facilitate prompt obedience on the part of the egg, hold it vertical, with the large end downward, while it is being boiled. To make the trick still more easy to perform, lay the plate on a table with the edge projecting beyond that of the

table, and then start the egg spinning by use of the thumb and fingers. The projecting position



of the plate will enable you to grasp this latter quickly with the right hand, and then all that you will have to do will be to keep the egg spinning by giving the plate its rotating motion.

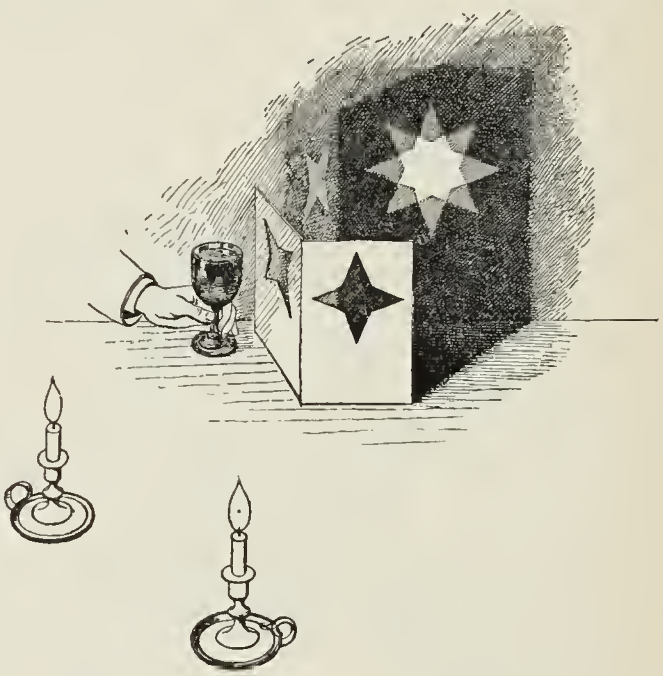
TO BLOW A COIN OUT OF A GLASS

It would seem, I admit, a bold statement to say that you could put a penny (or rather a "cent" in America) in the bottom of a wine-glass, cover it up with a dollar, and then, without touching either coin, blow the cent out of the glass without removing the dollar from the latter. Yet it can be done—if you know how. The cent is laid in

the bottom of the glass "sure enough," as they say down South; then the dollar, which is very much larger, is laid in so that it lies in a horizontal plane at some little distance above the cent. Now to get the cent past the dollar and out of the glass with the breath alone, blow sharply downward on that side of the upper face of the dollar which lies next to you. This will cause the coin to tilt as though on an axis; and the cent will be blown, by the current of air reflected from the bottom of the glass, past the dollar and up out of the glass.

THE THREE-COLORED STAR

To produce this pleasing and remarkable effect, take a square piece of cardboard (say eight inches on a side) and fold it down the center. In one of the divisions draw and cut out a four-pointed star with the arms vertical and horizontal; lay the piece cut out from here on the other division of the cardboard, but with the arms



diagonal, and having marked its outline exactly, cut out that star. Stand the card on end, as shown in the figure, on a table which is pushed close to a white wall, or on which is stood a white screen. Place two lighted candles on the table in such positions that the stars cast by the openings in the card fall together on the wall, making an eight-pointed star. Now, holding a piece of colored glass, paper, or gelatin, or a glass of colored liquid, between one of the candles and its corresponding star, the eight-pointed light star on the wall will be three-colored, the colors varying with the color used for the screen. Where a red screen is used to color the light falling on one four-pointed star, the eight-pointed star will be red, green, and white. If a yellow screen be used to color the light, the eight-pointed star will be yellow, purple, and white, etc. This is a good exercise in "complementary colors."

QUEER ERRORS OF THE EYE

BY ARCHIBALD HOBSON

WE all cherish the notion that our eyes can make no mistake. We depend on our sight more than on any of our other senses. Civilization has dulled for us our smell and hearing, and our taste and touch play but small parts in our life. The average person does not pride himself on his keenness of smell, hearing, touch, or taste, but he would be loath to admit that he could not "believe his own eyes." Notwithstanding, there are many cases, as we shall see, in which the eye shows itself to be but a poor judge of facts, incapable of telling to the mind a truthful story of what it sees.

In Fig. 1 the light vertical line EF looks longer than the heavy horizontal line GH, though both are of the same length. This illustrates the principle that a narrow object looks longer than a wide one of the same length, and that a vertical line looks longer than a horizontal one of the same length. Stout people look short because our eyes naturally discount their height, while thin people appear taller than they really are. Young ladies with an ambition to look stately cultivate meager, clinging effects in dress; short women select patterns having perpendicular stripes, and exceptionally tall women avoid such. Paper-hangers who understand their trade put a narrow border round the top of a low room. Large patterns in wall-paper or carpets make a room appear small and ill-proportioned.

In Fig. 2 the segment J appears easily larger than the segment I, but in reality they are identical in shape and extent, and if you were to cut out the two one would exactly cover the other.

The sides of the ladder shown in Fig. 3 appear to be closer together at L than they are at K, but they are really parallel. The effect is due to the oblique cross-hatch or section lines. Draftsmen are frequently embarrassed by illusions of this kind, which often give drawings a distorted appearance notwithstanding their technical accuracy.

If you were told that the lines MN and OP in Fig. 4 were straight and parallel you could hardly accept the statement; yet you can easily see that this is so by looking along the two lines from either end, or by measuring.

The black spots in Fig. 5 and the white spots in Fig. 6 are of the same size, but the white spots look the larger. This is due to the phenomenon of irradiation, which always makes a bright object against a dark background appear larger than it really is, owing, as Humboldt found, to the imperfect focusing of the object on the retina of the eye in such cases. By reason of irradiation the stars appear to our eyes larger than they otherwise would; and, to descend to the every-day, women well understand that in dress-goods light "polka-dots" on a dark ground look larger than dark ones on a light ground. Certain microscopic animals have markings which for a long time were taken to be hexagonal spots, giving a honeycomb appearance; but more powerful microscopes have shown these spots to be round. By partly closing the eyes and looking at Figs. 5 and 6 the spots will assume the hexagonal shape, thus illustrating this puzzling illusion.

Fig. 7 represents an adaptation of the famous illusion discovered by Professor Silvanus P. Thomson. By giving the page a slightly twirling motion similar to that used in rinsing out a dish, the cog-wheel on the left is made apparently to revolve slowly, while the wheel on the right turns rapidly in the opposite direction. This illusion is one of the most interesting and remarkable known. A variation of it is shown in Fig. 8. When this design is twirled as before, the six wheels appear to revolve rapidly, intermeshing with one another, while the central cog-wheel revolves very deliberately in the other direction, giving the appearance of a rather complicated piece of machinery in motion.

Printed letters show how usage has come to recognize certain peculiarities of vision, even without their being understood. The letter S, the figure 8, and the letter B appear to be symmetrical or practically so; but if you turn the page upside down you will be surprised to see how very much larger their lower parts are than their upper parts. Unskilful sign-painters and letterers do not understand this illusion, and they construct

FIG. 1.

all such letters and figures symmetrical by measurements, with the result that their work will appear distorted and inartistic when finished. The cross-line in the letter A should appear about midway of the height of the letter, but in order to produce this effect it must be made considerably below that point. By a gradual process of

evolution the letters and figures we use have grown into shapes that are satisfying to the eye, though they are not symmetrical.

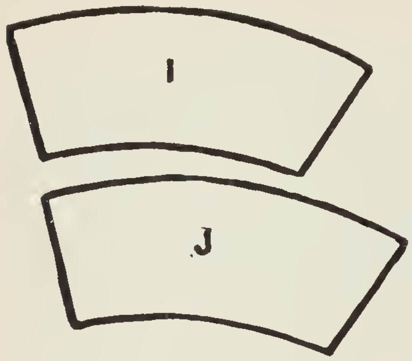


FIG. 2.

Fig. 9 shows an illusion of a very different kind. Place a visiting-card or a piece of paper with the edge along the dotted line between the bicyclists, look steadily at the figures, and then gradually bring your face closer and closer to the page, keeping both eyes open. The result will probably be that the reckless Chinaman and the timid young woman will have a collision.

In Fig. 11 we see a curious effect of the distortion of perspective. The figure of the man looking over the fence at the ball-game appears to be actually taller than that of the small boy who is peeping through the knot-hole, but in reality it is a little shorter. The illusion is due to the fact that we judge of size always by comparison. The eye sees the figure of the boy larger

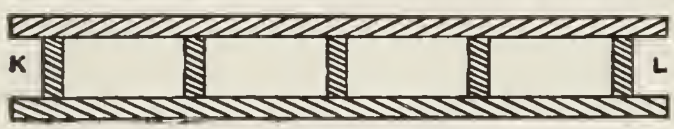


FIG. 3.

than that of the man, as it really is; but the man being represented farther away, the mind draws the conclusion that he must be the taller, for our daily experience is that distant objects must be larger than near ones having the same angle of extent.

We see everything, in short, by the light of experience alone. New-born babies, while they have eyes, see not. The eye is a camera pure and simple, and, until its impressions can be developed in the consciousness, what it sees means nothing. The baby first learns to distinguish

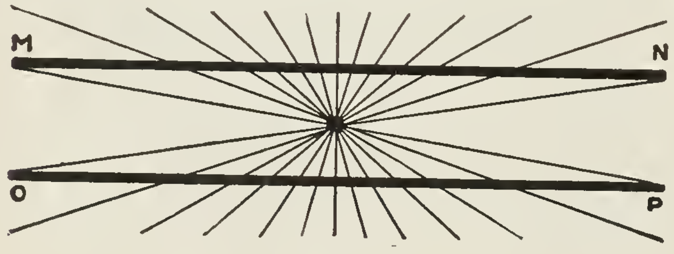


FIG. 4.

light from darkness; then it learns to recognize its mother, then its father; then it learns, perhaps, to distinguish some bright color, red it may be; then it learns to discriminate between near

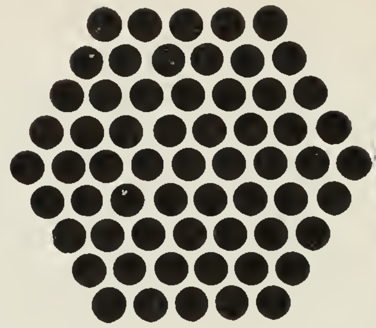


FIG. 5.

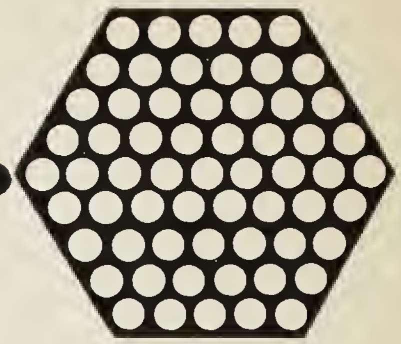


FIG. 6.

and far objects. It looks at the nearest house down the street and takes it to be of about the size of its Noah's ark, for so it appears to be. Later it goes to that house and discovers that it


FIG. 7.

is as big as its own house, which now, at a distance, in turn looks smaller. Gradually it makes its way from the known to the unknown, using its own experiences as stepping-stones. The eye


FIG. 8.

knows no such thing as size or distance in the abstract and apart from reasoning, but knowing

one by experience, it can make a close estimate of the other.

The average woman cannot judge how much a foot is within several inches, but she can estimate a yard very closely, while with the average man the case is reversed. If some one asked

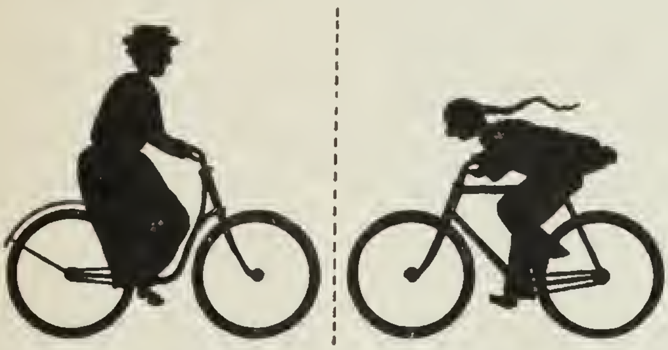


FIG. 9.

you which was the longer, a horse's head from the tip of his ears to the end of his nose, or an ordinary flour-barrel, you would naturally say the barrel, though the horse's head is the longer. The eye is very easily deceived if it is called on to pass judgment on something that has not been brought home to it by experience. The landlubber at sea greatly underestimates the distance of passing ships, having no familiar landmarks with which to make comparisons. Truthful men under oath in court often disagree widely as to observed facts, and no doubt with perfect honesty. We will not distrust our eyes, though no doubt they deceive us oftener than we realize.

The eye constantly overestimates an acute angle and underestimates an obtuse one. It is this principle on which the illusions shown in Figs. 3 and 4 depend. A right angle should be much easier to judge, but unless the eye is trained it will go astray considerably. Even a carpenter, who constantly deals with right angles, will not trust himself to saw a board off without a square if he has to make an accurate fit. Beginner's in drawing generally find themselves making all vertical lines lean slightly to the right. The buildings in their sketches topple quite uniformly in that direction, as shown in Fig. 10. The error becomes more evident when the drawing is turned on its side. And still a picture made with a ruler and T-square would lack the artistic quality. An artist would never use a ruler to draw a line by, for he understands that the eye demands something more than mere methodical accuracy of line and angle.

There should be an element of illusion in every picture, and the true artist is one who knows how to make allowance for this. So also in architecture. Measurements of the finest buildings left us by the ancients show us conclusively that the skilful architects of those old times understood perfectly about the illusive effects of lines on the eye, for they so designed their buildings as to counteract such defects of vision. The walls, instead of being vertical, lean in; tall windows are wider at the top than at the bottom; columns swell in the middle instead of being straight; the top lines of the buildings, instead of being strictly horizontal, are considerably higher in the middle, and so on. Without doubt

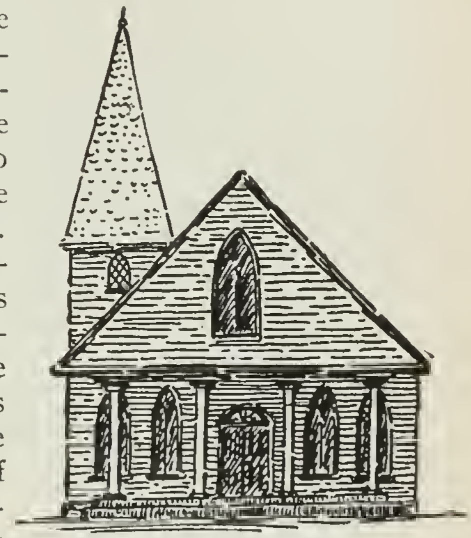


FIG. 10.

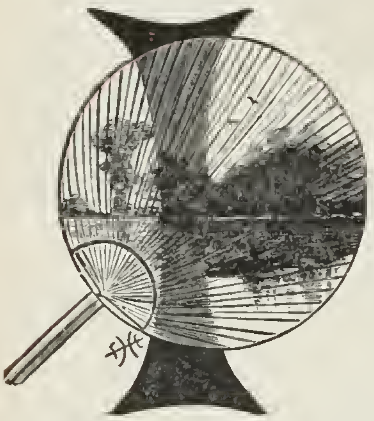
FIG. 11.

much of the beauty of these classic buildings was due to the recognition of such principles in their construction. Modern architects generally ignore everything of this kind and build strictly by the square, level, and plumb-line. There are fine buildings in every city that have been made to suffer in this way, for, though really well built, their walls appear to lean outward, or their cornices to sag in the middle, and so forth.

These various instances point the moral that our eyes do not by any means always see things as they are, and that if we are not taught how to accept their reports with a "grain of salt" we shall occasionally be misled more or less.

SEEING AND BELIEVING

BY HAROLD WILSON, M. D.



IT is an old and a wise saying that "seeing is believing," yet everybody knows that very often what we see, and therefore believe, proves to be not really true at all. As we grow older, finding that our eyes have so frequently deceived us, we are often not satisfied with the evidence they give us until we have verified it by touch or smell or hearing or taste, or by looking at some doubtful thing from different points of view, or under a different lighting.

We are not willing to believe that a conjurer actually draws rabbits from a man's ear or coins from the tip of his nose just because our eyes tell us such tales. Sometimes our deceptions are so lasting that things must be made wrong in order to look right, which seems rather contradictory. If we look at the letter S or the figure 8 as carefully as we can, the upper and lower halves seem to be almost exactly the same size. If we turn them upside down, thus, ƨ, 8, the difference in the size of the loops is quite astonishing, and we wonder how we could have been so mistaken; yet perhaps the truth is that the loops are neither so different nor so much alike as they seem to be, as we see when we look at them turned upon their sides, thus, ∽, ∞.

The eye is such a delicate bit of machinery, it has so many parts, and so many different kinds of work to do, and such long hours of labor, that it is not surprising, after all, if in the capacity of receiving-office for so many millions of light-waves every minute, it should occasionally send wrong messages to the central station in the brain. Nor is it to be wondered at if the mind itself, having so many other things to attend to at the same time, sometimes fails to understand what certain messages from the eye may mean. These mistakes on the part of the mind in interpreting the communications which the eye sends to it, are called *illusions of sight.*

Moreover, in the eye itself certain things may go on which give us wrong sensations, which, although not truly illusions, are very much like them. Thus, when we suddenly strike our heads or faces against something in the dark, we see "stars," or bright sparks, which we know are not real lights, though they are quite as bright and sparkling as if they were. When we close one eye and look straight ahead at some word or letter in the middle of this page, for example, we seem to see not only the thing we are looking at, but everything else immediately about it and for a long way on each side. But the truth is, there is a large round spot, somewhere near the point at which we are looking, in which we see nothing. Curiously enough, the existence of this blind spot was not discovered by accident, and nobody ever suspected it until Mariotte reasoned from the construction of the eyeball that it must

FIG. I. THE VANISHING DISK.

exist, and proceeded to find it. Now we can all find it very easily. If you will hold Fig. I straight in front of the right eye, and about ten and a half inches away from it, the left eye being kept closed, then look sharply at the center of the little cross, everything being properly adjusted, the round black spot will disappear from view.

Some of our most delightful sensations are those of color. Nature has given us a great profusion of them, but the eye is not satisfied with what it gets legitimately, as it were, but creates for itself a lot of imaginary colors, which are often very hard to distinguish from the real ones which the light makes. If we take a sheet of gray or white paper and place upon it a small piece of orange-red paper, look intently at the red paper for a few seconds and then suddenly take it away, we will see a patch of a light-green color, which moves about as we move our eyes, and soon fades away. A bit of yellow paper gives us a blue patch, green a violet red, and with a package of kindergarten color-papers to experiment with, the reader will find that each one has its own unchanging and especial successor when tried in the same fashion. These after-colors are the creations of our eyes, and are not really where they seem to be. They are quite as unreal as are other sorts of ghosts. With a candle or lamp, a few pieces of colored glass, and a lead pencil, we can display some other curious fancies of the eyes by making what are called colored shadows. Fig. 2 shows how it is done. Using red glass, the shadow of the pencil upon the wall (a piece of white paper is better) looks blue-green; with blue glass, yellow; with green glass, rose; and so on. It is hard to convince ourselves that the shadow is not actually of the color it seems to be, and if I did not tell you that it was an illusion, you might never discover the fact.

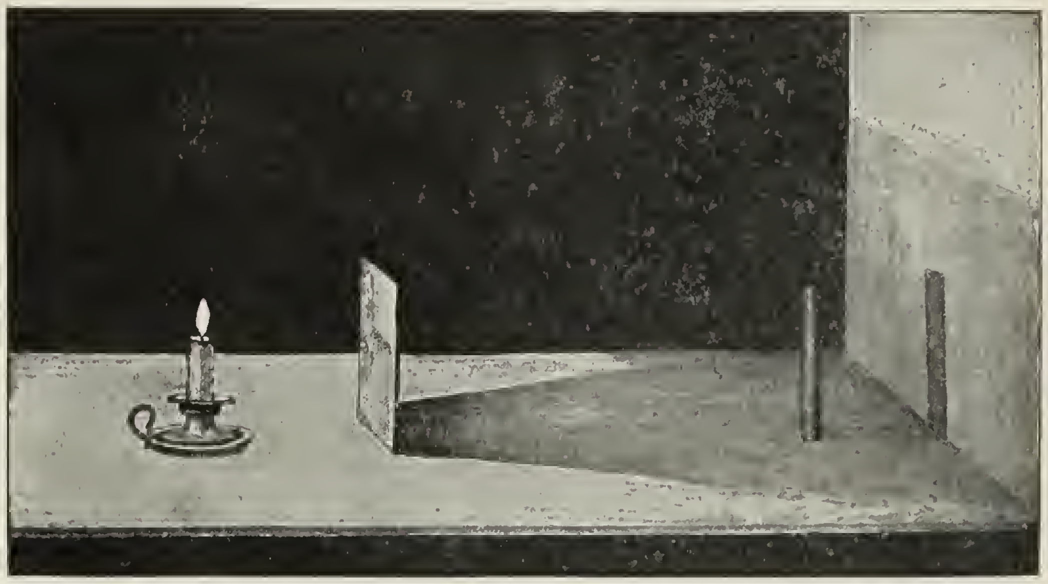


FIG. 2. THE COLORED SHADOWS.

FIG. 3.

When we come to study the shapes and sizes of things, we find that the eyes are often greatly deceived. We all know how large the full moon looks when it has just risen, and how much smaller it appears when it rides higher in the sky; and those of you who have ever looked at it through a telescope or a pair of opera-glasses know that although it is then magnified, it actually looks smaller than with the naked eye. Those who know tell us that the big moon we see at the horizon is an illusion, and that while it actually is magnified by refraction, it looks much larger because we see it a long way off, through the trees, or over houses, or down the street, and comparing it with those objects of which we know the size, fancy it must be very large because it is so far away; and that when up in the sky, or when seen through an opera-glass, it seems nearer, and therefore it appears to be much smaller.

In Fig. 3, the row of dots between *a* and *b* makes that distance seem greater than the distance between *b* and *c*, although upon measurement you will find it to be just equal. Fig. 4 does not look exactly square: the horizontal lines make it seem too tall. The artist was instructed to make the horizontal lines in Figs. 5 and 6 parallel to each other, and no doubt he has done so, although those in Fig. 5 seem very far from it, and it is perfectly plain *to the eye* that the upper ones in Fig. 6 separate more at the middle and that the lower ones come closer together there than at the ends; and if the top of the page is tipped away from you so that you look obliquely down at it, these appearances are all the more striking. Yet if we turn the page about and look at the drawings from the side, we see at once that the artist has done his work truly, and that it is our eyes that have been at fault. So, in Fig. 7, the circle seems to dip in or flatten at the corners of the square, yet it is positively a true and uniform curve. In Fig. 8 the line running upward on the right-hand side of the black rectangle is the direct continuation of one of the two lower lines on the left. Everybody says that it is with the upper one of these lines; and as we examine it carefully, running the eye back and forth so as to be sure, this certainly

FIG. 4.

seems to be true. But hold the figure so as to look along the line as a carpenter looks along the edge of a board, and it is surprising to see how much we have been mistaken.

If I were to ask what Fig. 11 represented, most persons would say that it was a picture of a transparent cube of which three faces were visible,—the one toward you, the upper, and the left-hand one,—as is shown in Fig. 10. Some other person looking on might say, however, that it was a cube showing the *lower* and the *right-hand* faces, as shown in Fig. 9; and upon looking at it again, sure enough, this seems to be so; and yet, while we still look at it, it suddenly changes, and once more looks like Fig. 10. With a little practice, we discover that we can make it look either way at pleasure, though it has an uncomfortable fashion of turning about of its own accord. Generally we can see it like Fig. 10 more easily, perhaps because that is the way most real cubes appear as we look at them usually from above. So Fig. 12 we can see either as a flight of steps leading up to the left, or as an overhanging or upside-down stairway which we could climb only by standing upon our heads. It is a little hard to see these two stairways, and you may succeed better by turning the page around while looking at the drawing. It is easy, sometimes, to see objects that do not exist: thus, in Fig. 13, if the page is tipped a little and held so that the right eye looks along the line *a b*, and the left along the line *c d*, both eyes being open and looking at the point where the two lines cross, a third line is seen standing right up from the paper like a little rod or pin. Fig. 14, when

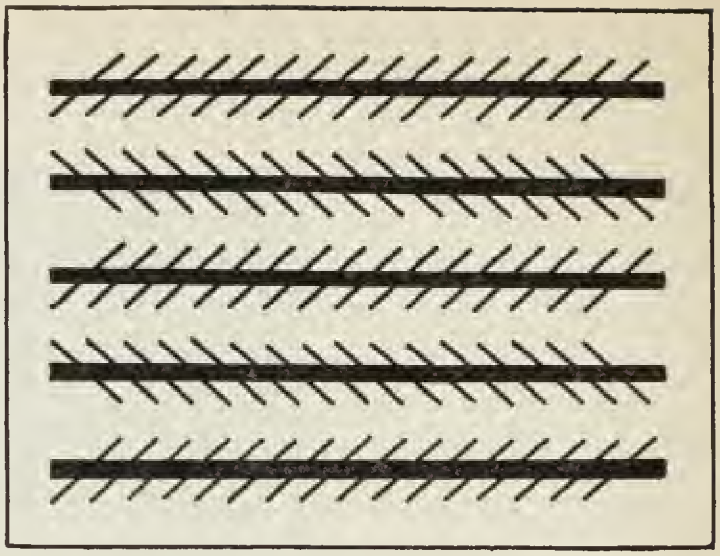


FIG. 5.

FIG. 6.

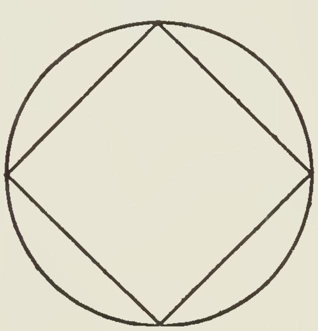


FIG. 7.

FIG. 8.

looked at with one eye from a point where it can look along all of the lines without moving the head,—that is, at a point where all the lines would meet if they were drawn long enough,—shows a lot of black pins standing upright as if stuck into the page.

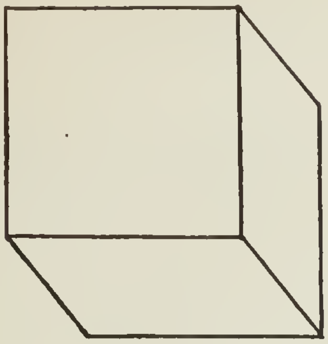


FIG. 9.

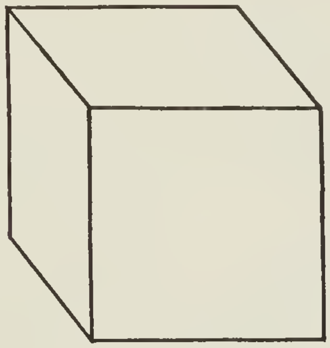


FIG. 10.

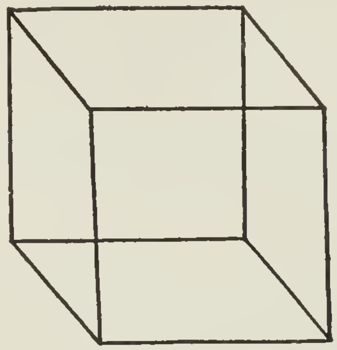


FIG. 11.

In the picture at the end of this article, it will be found interesting to let the spectators guess which of the stones in the Magic Bridge is longest, and also to estimate the precise difference in length between the upper and lower pair. After the guesses have been made, measure them; it will be instructive.

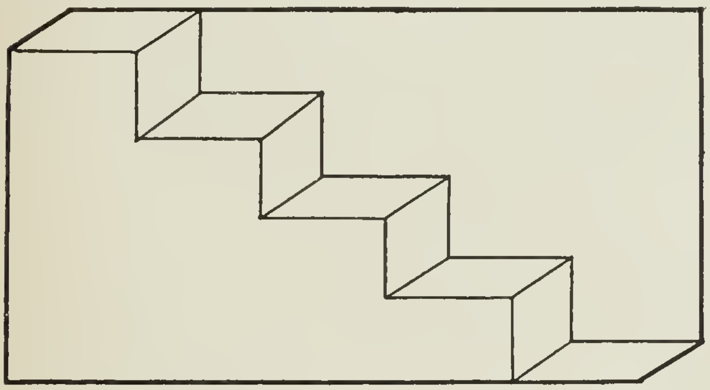


FIG. 12.

Now, we all want to know, of course, how these curious illusions come about, and whether there are others than those we have just seen. Yes, there are many others, and men have known them from very early times. Long years ago the Greek architects took advantage of these illusions to improve the appearance of the temples; and it has lately been found that the cathedral builders of the Middle Ages also so arranged their lines and curves as to deceive the eye. Figs. 15 and 16 show how two lines of the same length may be by branching lines made to look quite unequal; but it is a great deal easier to see that they are illusions than to explain why we are deceived in them. Even the wise men who have studied them do not always agree in their explanations. And then, to understand

FIG. 13.

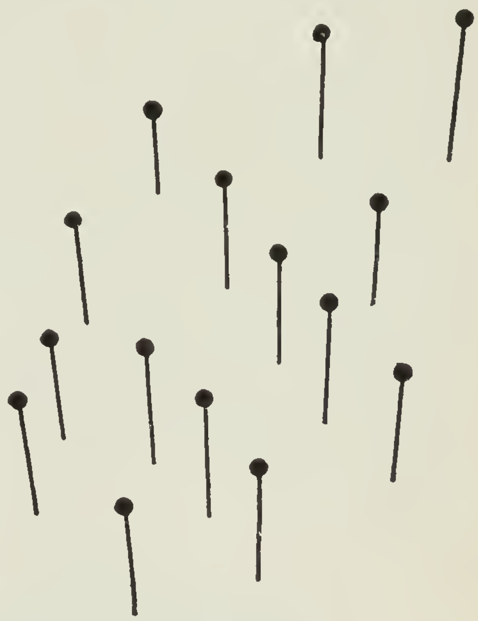


FIG. 14.

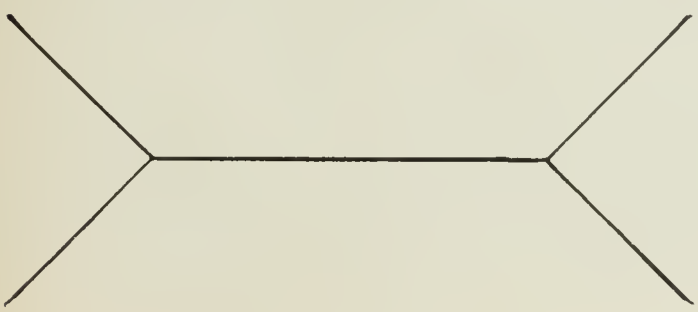


FIG. 15.

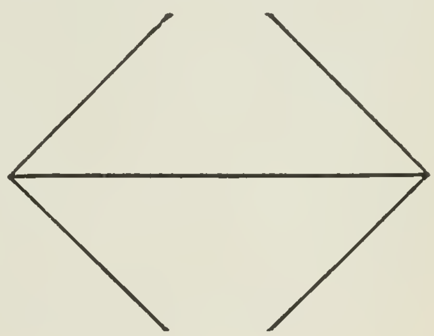


FIG. 16.

these explanations, we have to know a great many things that are not so interesting. Besides, what we need most of all to know about them is the fact that they exist, and that often "things are not what they seem," and that seeing ought not always to be believing. Our eyes must be trained to beware of tricks that may be played upon them, and where our eyes deceive, our brains must help us to find out the truth, even in the midst of apparent error.

WHY THE STARS DON'T TWINKLE

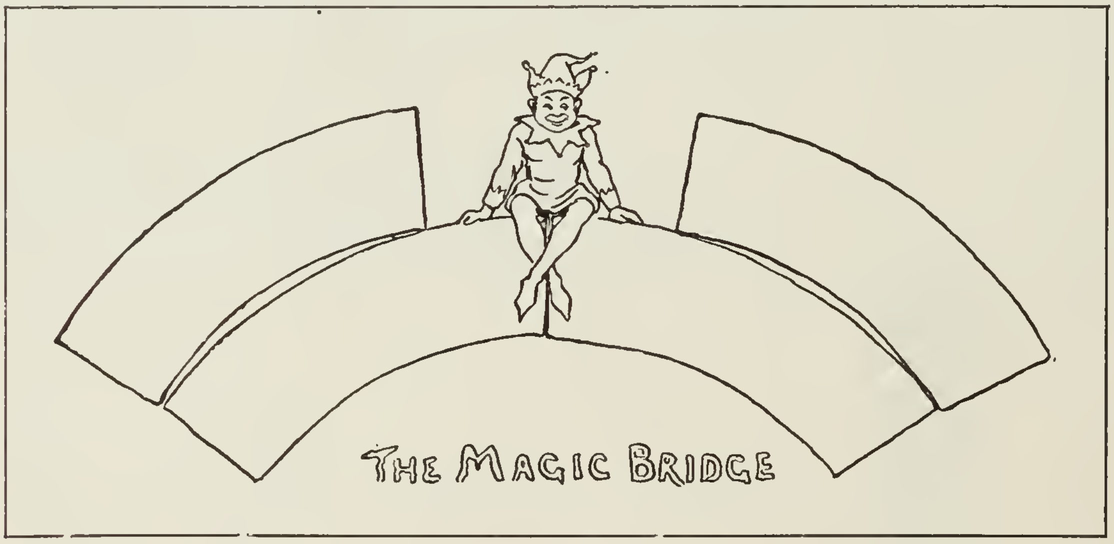
Every cloudless night the eyes make a mistake that we can easily discover, but which we are totally unable to remedy.

Of course you have looked up to the sky thousands of times and seen the stars twinkling. Not only that, but if the night is clear you can see they are stellate, or star-shaped, like the starfish which is named after them. You can see both of these things, and yet the strange fact is that neither of them is true!

The stars do not twinkle at all, and they are not stellate. The twinkling is the result of the intervening atmosphere, and not the fault of our eyes; but the second error can be easily brought home to our untrustworthy organs of vision by the following experiment.

Take a piece of tinfoil and prick a small hole with the point of a pin. Now when it is dark put a candle behind the tinfoil in such a way that the light comes through the tiny hole. Hold the tinfoil about ten inches from your face, and the hole will appear irregular. If you bring it nearer, it will lose even the least resemblance to a hole and appear as a star! Of course you know perfectly well that it is round, but your eyes have deceived you once more in the same way that they deceive you every starlight night. This deception, or to put it charitably, this mistake of the eyes, is given the very high-sounding name of "irregular astigmatism," but for all that it is an illusion pure and simple.

Like many well-trained servants, the eyes are quite at a loss if anything contrary to the usual routine is presented to them. They know perfectly well the laws of perspective,—how in the ordinary course of nature these laws are never broken by a hairbreadth. They are therefore accustomed to judge in the fraction of an instant the size of an object by its apparent distance away. That this is the result of practice can be easily seen from the fact that very young creatures—human and otherwise—have no idea of the relative distances of objects, and strain to touch a distant gas-light, or, like a young calf, rush headlong into a neighboring wall which their green young fancy deludes them into thinking is really some distance away. But as we grow older we may learn many things, and perspective among others.



STRANGE FISH AND REPTILES

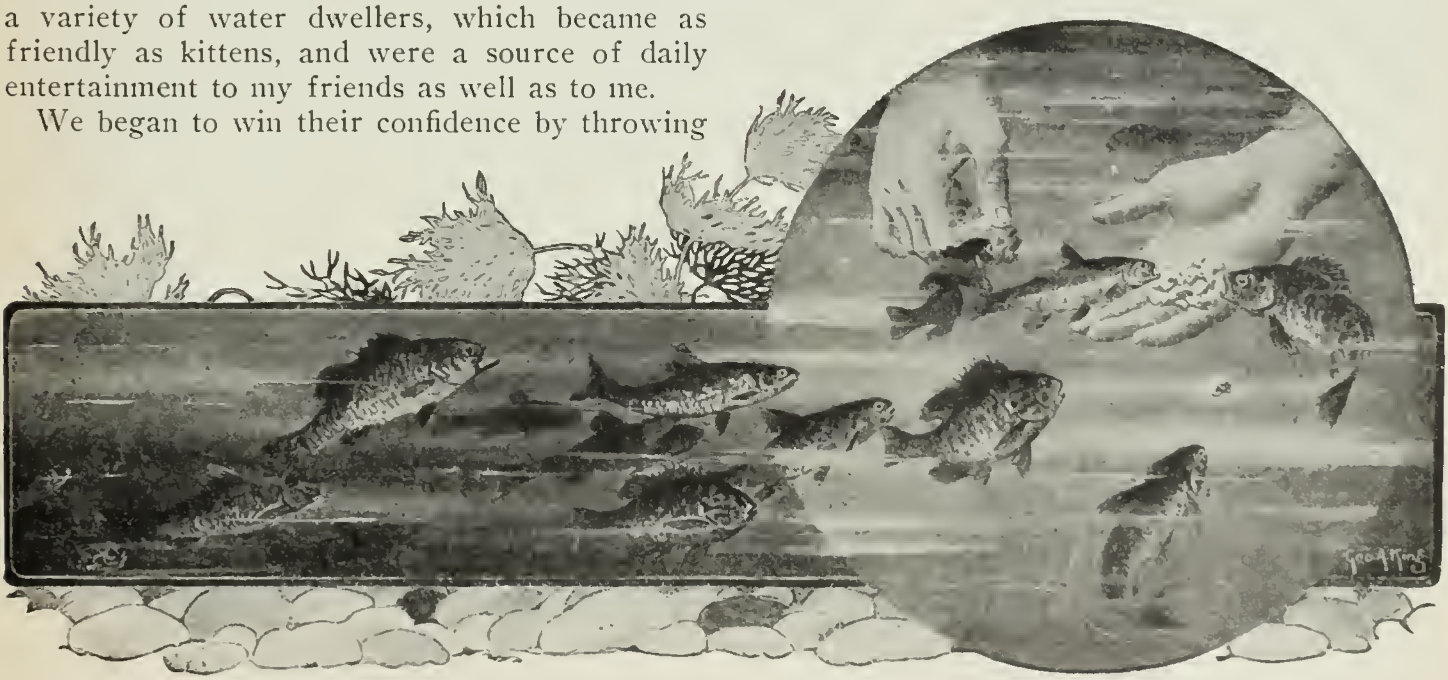
OUR WATER PLAYMATES

TAME fish are not common pets, yet they are very interesting, as I have found from experience. That others, if inclined, may find ways of enjoying the dwellers of the deep without taking their lives, I will tell of a school of fish that entertained us one summer on the shores of Lake Minnetonka.

Even as a child I seemed to have rather an instinctive feeling of the ways to make acquaintance with those little dwellers in another element, and I always carried a slice of bread in my dinner basket to drop to the minnows in the brooklet we passed on the way to school; but not being allowed to go down to the water's edge, I never knew them or their habits of life very fully. When I came to live on the lake shore, I gathered a variety of water dwellers, which became as friendly as kittens, and were a source of daily entertainment to my friends as well as to me.

We began to win their confidence by throwing crumbs to them as we sat in the boats under the willows, but noticing it was hard for them to come to the surface for food, I tried holding bits of bread in the water. At first they all sped away, but were soon back again investigating my hand, shyly, but coming nearer and nearer, till one ventured to nip the bread. It was good and harmless, and he tried again. Another came, another and another, till courage, which is everywhere contagious, spread among them, and as the days went by they seemed almost to forget fear and always swam eagerly to meet us when we went down to the lake shore.

For a time I always whistled to call them in, but later I went silently and found them just as ready to greet me as when I called. I noticed, though, that if we ran out on the pier heavily, or

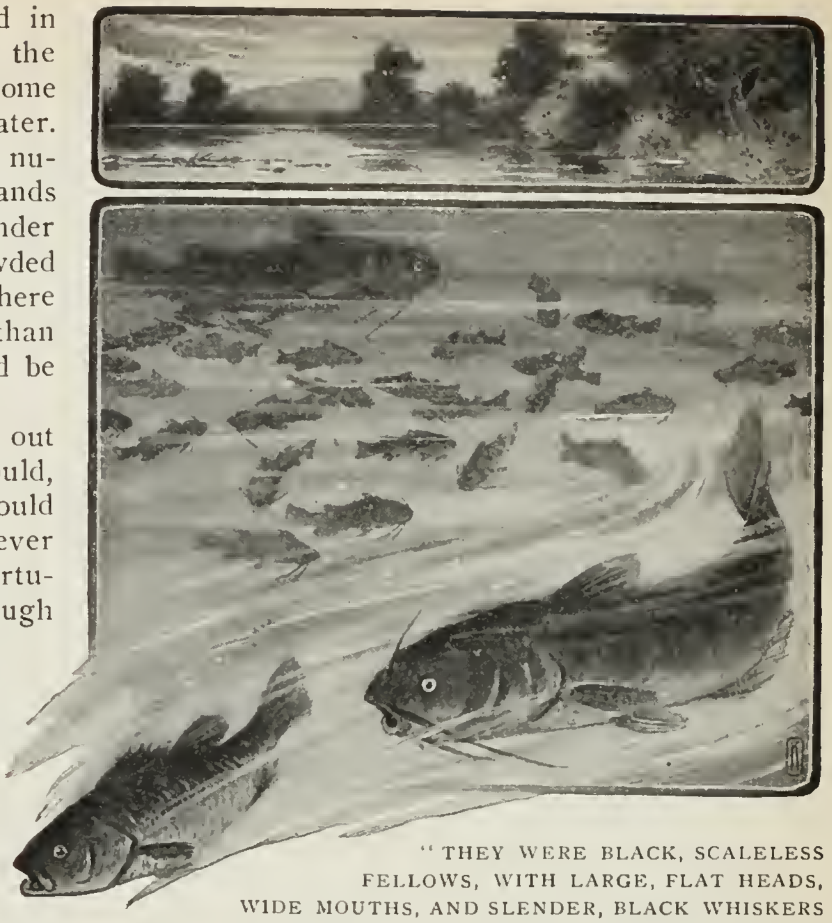


"NOTICING IT WAS HARD FOR THEM TO COME TO THE SURFACE FOR FOOD, I TRIED HOLDING BITS OF BREAD IN THE WATER."

rocked a boat on the water, they flocked in more speedily, which fact coincided with the observations of scientists, that fish are in some way very sensitive to vibrations of the water.

In our bay the sunfish tribe was most numerous and fearless. I often put my two hands together like a dish, and holding them under the water they were instantly filled, crowded with the soft, velvety little things. There never was anything smoother and softer than a living fish in water! Rose petals would be rough in comparison.

We never startled them by taking them out of the water; had we done so the spell would, doubtless, have been broken and we should have had no tame fish. The only one I ever took from its native element was an unfortunate that had been lured by a hook and though escaping with his life had the hook still hanging in his mouth. This I removed and returned him again to the water, relieved from what was probably a painful inconvenience, though terrified and distressed; but after performing that surgical operation I was never able, if he remained with us, to distinguish him from others.



"THEY WERE BLACK, SCALELESS FELLOWS, WITH LARGE, FLAT HEADS, WIDE MOUTHS, AND SLENDER, BLACK WHISKERS GROWING JUST ABOVE THE CORNERS OF THE MOUTH."

These little fellows grew very fast with the good living provided, but we no more thought of making a meal of them than of our sweet-voiced canaries.

At the end of the pier, under a sunken log, where a few water plants had taken root, was a family of catfish, horned pout, that joined our group. They were black, scaleless fellows, with large, flat heads, wide mouths, and slender, black whiskers growing just above the corners of the mouth. Not great bread eaters, but ravenous when offered a piece of meat. It was very amusing to give them a bone to pick, to feel their strong pull as they snatched it away, and see them dash down to the bottom of the lake with it, looking as if they stood on their heads; then rushing about till the water was turbid with their efforts to devour the last morsel.

One morning a long, slender pickerel came and made his abiding-place with us. He was very much of an aristocrat, always holding himself a little aloof from the others, and never tempted to come to their table by any variety of food I could offer; though he came close and seemed never offended when I stroked his smooth sides. I always noticed what a cruel-looking face he had and wondered if it was because he was very hungry. Most of the time he held himself nearly motionless in the water, but when he did move it was like a lightning flash; then all his finny companions disappeared. Making a circle through the water he would return to his usual position near the boat, watching with his set eye as if he were the appointed ruler there.

After a time, my brother coming down to the lake saw him, and asked, "How long do you think your school of fish will hold out to feed that cannibal?" The words were a revelation. It was surprising I had never suspected his strange manners, especially as I had noticed that he always seemed to be swallowing something when he returned from his flights through the water. "Beside," Brother added, "he could snap off your finger at a single bite if he chose."

There was no longer a welcome for our pickerel; instead, a willow branch was struck vigorously through the blue waves whenever he approached, and soon he came no more.

Some turtles found us out and four came regularly to meals. Two were about eight inches in diameter, the other two not more than four or five inches. Their shells were beautiful on the under side, mottled with red, yellow, and brown. I never felt very trustful of them and always took a large piece from the dish when I saw their black heads drifting through the water. To this they would swim and, resting their front feet upon it, bite off one mouthful after another till satisfied, never seeming very particular what kind

of food was provided; then they would go to the shore and doze in the sunshine.

Among the smaller varieties in our group, the least trusting and the most beautiful was the yellow perch. Their greenish golden sides, banded with narrow lines of black, glistened where the sunlight pierced the water and always called forth expressions of admiration. But few of them came, and before summer was gone, all seemed to have disappeared.

The most friendly, undisturbed individual in our living collection was a black bass. He was a little more than a foot long when we first noticed him. He seemed to make his abode in a growth of water-mosses near a fallen tree, and no one ever went down to the shore that he did not swim majestically out to meet him, opening his great mouth as he neared the surface for an expected morsel, and very seldom was he doomed to disappointment. If we were slow in offering it, he would come as close as possible to shore, never hesitating to eat from out our fingers, seemingly no more afraid of us than we were of him.

He was a rollicksome, jolly fish, never troubled about the necessities of life, and seemingly satisfied with its conditions. Every one felt like laughing when one saw him, and it really seemed as if he enjoyed companionship.

He remained with us till we left the lake, and one of the family going out to the cottage in November found him still there, and seemingly glad to see an old friend.

"I SAW THEIR BLACK HEADS DRIFTING THROUGH THE WATER."

It was a pretty sight when our yacht steamed out from shore to see the wake of fish that followed it; and it was especially pleasing to watch them come to meet us on returning, as they always did.

No one thing gave us more pleasure during that happy summer by the lake than our tame fish, yet we resolved never to feed them another season, for our bay grew to have a reputation as a fishing-ground, and it was very grievous to see the stolid, old fishermen sitting by the hour pulling into their boats the trusting little creatures that we had disarmed by dispelling their fears. But for one who has a lake or stream wholly his own, I know of no pleasanter pastime than making friends with the dwellers there.—Sarah A. Jenison.

"WHEN HE DID MOVE, IT WAS LIKE A LIGHTNING FLASH."

THE TOAD UNDER THE BRICKS

Sometime near the last of June we were removing the bricks from a short walk in order that we might replace them with others to match the pattern of the walks around the house.

Near the center of the walk, and about equally distant from either side, we found under the bricks, in a space just large enough to accommodate him, a full-sized toad.

It is not at all probable that he could have burrowed from either side of the walk beneath the bricks, and it was utterly impossible for any but the tiniest of toads to have forced a way between

the bricks, as they were placed as closely together as bricks are usually laid, and were in perfect condition.

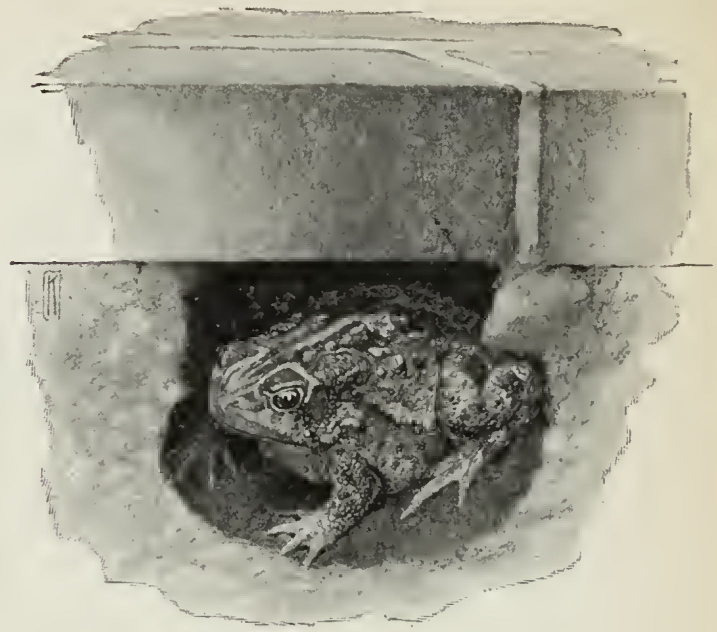
He was not in the most excellent flesh; in fact, was a pretty slender specimen of toad; and was disinclined, at first, to exert himself at all. He sat very quietly and blinked when we poked him gently, and only showed a feeble inclination to hop when we had removed him forcibly from his cave.

We watched him for a day until he became more familiar with our back yard, and were gratified to find that the hopping instinct was there all right, and only needed space for rapid development.

How and when had he got into his subterranean home, how long had he lived there, what had he lived on, and why, if he had a way to get out, had he not been out sooner, when all ambitious toads had been reveling in flies and bugs and summertime for a month or more?

Olive Rachel White.

The common toad has a marked habit of burrowing under brick walls. I think he does this owing to his discovery that bricks absorb a comfortable amount of heat from the sun, and while he is in

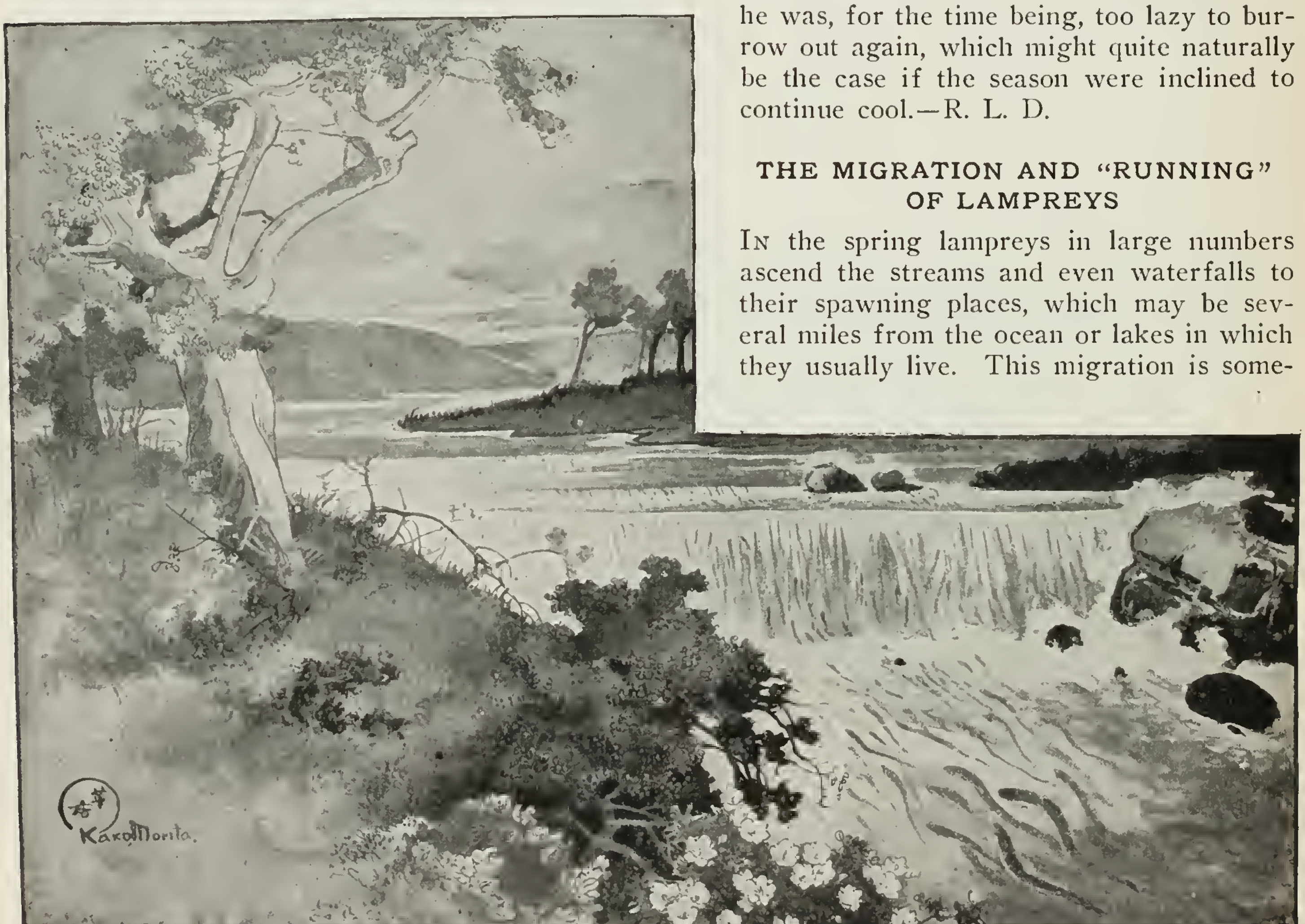


THE TOAD UNDER THE BRICKS.

darkness during the day, as he desires, he is also well-warmed. This toad, of course, burrowed in from the side. It is possible that the earth was of a consistency that caved in after him and he was, for the time being, too lazy to burrow out again, which might quite naturally be the case if the season were inclined to continue cool.—R. L. D.

THE MIGRATION AND "RUNNING" OF LAMPREYS

In the spring lampreys in large numbers ascend the streams and even waterfalls to their spawning places, which may be several miles from the ocean or lakes in which they usually live. This migration is some-



THE LAMPREYS ASCENDING A STREAM AND WATERFALL.

what similar to that of birds that go north in the spring to build nests and rear their young. Professor H. A. Surface, who has studied the lampreys (principally in New York State), thus writes:

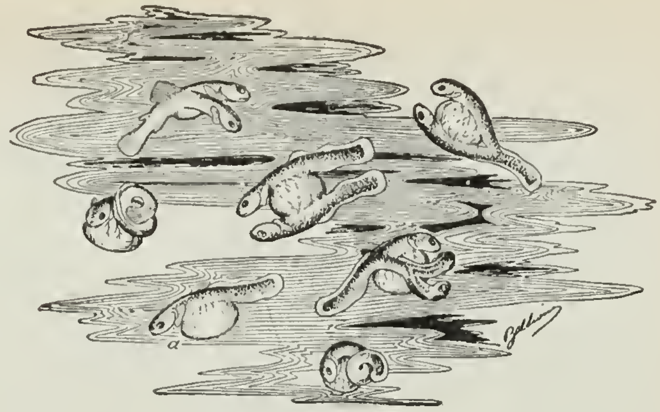
"In this migration they are true to their instincts and habits of laziness in being carried about, as they make use of any available object, such as a fish, boat, etc., that is going in their direction, fastening to it with their suctorial mouths and being borne along at their ease. During this season it is not infrequent that as the Cornell crews come in from practice and lift their shells from the water, they find lampreys clinging to the bottoms of the boats, sometimes as many as fifty at one time. They are likely to crowd up all streams flowing into the lake, inspecting the bed of the streams as they go. They do not stop until they reach favorable spawning sites, and if they find unsurmountable obstacles in their way, such as very high vertical falls or dams, they turn around and go down-stream until they find another, up which they go. This is proved every spring by the number of adult lampreys which are seen temporarily in Fall Creek and Cascadilla Creek. In each of these streams, about a mile from its mouth, there is a vertical fall over thirty feet in height which the lampreys cannot surmount, and in fact they have never been seen attempting to do so. After clinging with their mouths to the stones at the foot of the falls for a few days, they work their way down-stream, carefully inspecting all the bottom for suitable spawning sites. They do not spawn in these streams, because there are too many rocks and no sand, but finally enter the only stream (the Cayuga Lake inlet) in which they find suitable and accessible spawning sites.

"In 'running' they move almost entirely at night, and if they do not reach a suitable spawning site by daylight, they will cling to roots or stones during the day and complete their journey the next night.

"They do not swim readily over a fall, but cling with the mouth to stones, and jump and catch and cling and jump again. If the falls be low, they of course could go over them, but I have seen them clinging in the way I describe."

QUEER LITTLE FISHES

Baby fishes sometimes appear in as strange forms as the famous Siamese twins. Our illustration shows a few of these little fishes selected from a collection of fifty thousand newly hatched rainbow trout, at the Central Station of the U. S. Bureau of Fisheries.



THE QUEER LITTLE FISHES.

Among the many millions of trout and salmon from the government hatcheries these odd forms are sometimes found. Usually the twins are attached on opposite sides of the same egg-sac and are otherwise normal in form, like the fish shown in the sketch by *a*. Two-headed and, very rarely, three-headed forms occur, and curiously twisted specimens, with corkscrew tails. Although lively enough when first hatched, most of these abnormal fishes do not survive longer than the period of ten or fifteen days necessary to absorb the food of the egg-sac, and it is unlikely that they would live any longer in natural conditions.

A. H. Baldwin.

A SIMPLE TURTLE TRAP

Any stout box about eighteen or twenty-four inches square and eighteen inches deep will answer the purpose. Bore a few holes in the bot-

A TURTLE TRAP SET IN A SMALL POND.

"WAIT FOR A FAVORABLE CHANCE TO GRAB THE UPPER AND LOWER JAWS."

tom and sides for water circulation, nail an inclined board as a gang-plank on one side extending from the water to about over the center of the box.

The box should be weighted with stones to keep it level, leaving only about six inches above the water. The trap is then ready to anchor in any convenient place in the pond or lake.

The turtles in selecting a fine spot in which to sun themselves will invariably crawl to the highest point of the gang-plank, directly over the center of the trap. It is then necessary only to throw a stone from a distance in order to make a good splash near the trap. The turtles becoming frightened will slip off the gang-plank into the trap.

The writer has caught many turtles in this manner in a very short time. W. L. Bedell.

HANDLING ALLIGATORS

There is a man with the quite unheroic name of Bert Swan who catches alligators with his hands, turns them on their backs, and makes them as helpless as infants. The alligators that Swan does this with are not the giants that bask in the mud of tropical rivers, but they are sufficiently formidable nevertheless. It is wonderful with what quickness these saurians can snap at a man.

Swan gave a little session with his pets for the benefit of the camera man, and this quickness of action on the part of the alligators was fully demonstrated before the little private performance ended.

The first task was to get the alligator into the open where the light was sufficiently good to permit of snap shots. This was done by two men grasping the alligator, one seizing his jaws with a lightning movement and the other grabbing his wildly waving tail. In the open the alligator proved as wicked as could have been wished. Swan's method of catching him was to hold the hands in readiness and wait for a favorable chance to grab the upper and lower jaws. As this was done while the formidable rows of teeth were apparently aching for a chance to snap the man's arm, it was no simple matter to catch the jaws and imprison them.

Swan waited a long time before he saw his chance, and the eye could scarcely follow the movement of his hands as they were darted toward the outstretched jaws. Once the jaws were closed in the man's vise-like grip it was a simple matter to slip one hand under the snout, seize one of the clawing legs with the other, and turn the alligator on his back.

The owner of the alligator says he has found

A CURIOUS PLAY WITH THE ALLIGATOR.
The mouth opens when the hands are held apart.

a way to hypnotize the creatures. Be that as it may, it is true that he made the wicked little saurian lie perfectly still for as long a time as he wished, and then raised him in his arms and carried him around like a baby, the animal being apparently sound asleep all the time. When Swan put him down and touched his throat with a finger, he awoke once more into vicious life and began snapping as before.

The alligator cannot move very quickly on his legs, and it is easy enough to avoid him when he comes at you, but to try and pinion his jaws is another matter, and a task that no one would care to try unless gifted with lightning-like agility and the quickest of eyes, as well as with muscular hands.

Small alligators may be purchased at most animal stores, and are as easily cared for as are frogs and turtles. H. D. Jones.

A MUCH ADVERTISED TOAD

After a blast about one hundred feet below the surface in the lime rock of a mine thirty miles north of Winnemucca, Nevada, Mr. Charles Van

THE TOAD THAT WAS FOUND IN A MINE.
Photograph by courtesy of the New York Zoölogical Society.

Zandt (a Butte, Montana, mining man) picked up among the pieces of rock a much dazed toad. Undoubtedly it was a very interesting form of animal life (most toads are), and it was in an unusual place. It would be interesting to know by what series of cracks and crevices he got down there or how long he had been there without food or what food, if any, he had obtained.

But all these queries are excelled in interest by the astonishing messages sent all over the country by the Associated Press, and the industry and zeal with which almost every newspaper in the United States served up the great "information" for the news appetites of its readers. The toad was undoubtedly there, it was found by Mr. Van Zandt, and it later was given a fly to eat. This last fact was announced in such startling headlines as "Pythagoras, the Toad, Eats His First Meal in a Thousand Years."

Mr. Van Zandt kept the toad at his home in a porcelain jar for about seven months, the little animal steadily refusing all food. A representative of the miner coming to New York reported the matter to Dr. Gratacap, at the American Museum of Natural History, and he at once referred it to the New York Zoölogical Park, where the toad was placed on exhibition in the Reptile House.

Mr. Raymond L. Ditmars, the manager of that house, made a statement as follows:

> It 's pretty hard to form any definite opinion as to the age of toads found "imprisoned" in rocks, etc. I really believe that a toad might live for a hundred years under *normal* conditions. I have known them to live for a year without food and be normally active. It is quite possible an imprisoned toad, with partially suspended animation, might live many years. The matter is one of theory only, however. I am after proof as to how long this toad was a prisoner. He might have worked his way downward through a series of continuous crevices, and in this case would have undergone no abnormal fast.

This particular species of toad is known as the "spade-foot," and is famous for its underground habits.

Miss Mary C. Dickerson, a careful student of toads and frogs, writes of its habits in "The Frog Book" (Doubleday, Page & Company) as follows:

> It burrows into the ground and sleeps days or weeks, *perhaps years*, at a time. A gravedigger once found one three feet two inches from the surface of the ground, with no evident exit to the burrow. . . . Except during the breeding season, the spade-foot is found only by accident. It sits in its burrow, showing only its peculiar golden eyes at the doorway. The turnip-shaped burrow is about six inches long and somewhat oblique in position. The earth on the interior is hard and smooth, packed into this condition by a continued energetic turning-about on the part of the owner of the burrow.

It is true that the habits of this species and the location of this particular specimen are astonishing, but in this respect have not equaled the many statements that have recently been printed with startling headlines.

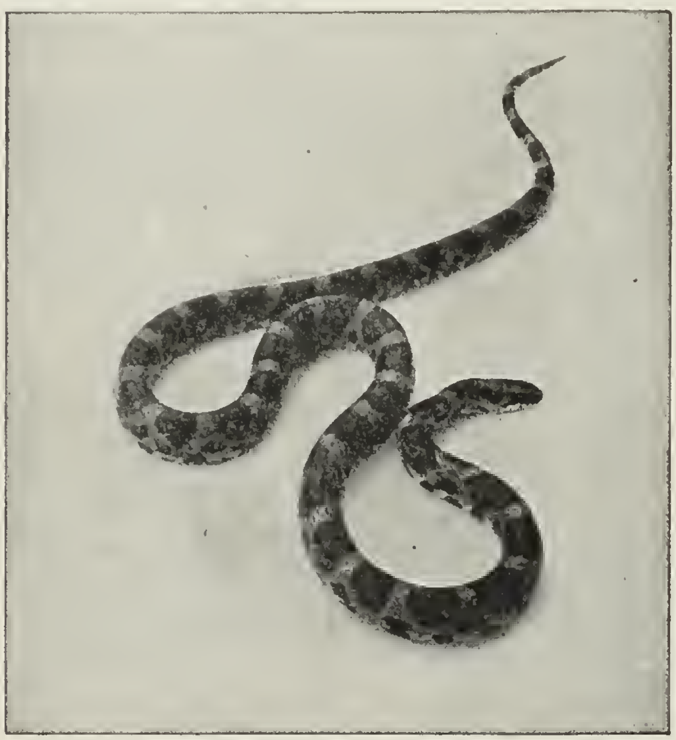
THE HOUSE-SNAKE; ALSO CALLED THE MILK-SNAKE

My grandmother was sitting one day in her armchair in front of an old-fashioned cupboard, when, to her very great surprise, a house-snake fell into her lap and wriggled to the floor. In

some way the snake had found its way into the house unobserved, perhaps through an open door or window, and had crawled to the top of the cupboard in search of food.

The first name given to this reptile was well chosen, for it is found about houses and other buildings more frequently than any other snake. I remember when I was a boy in the country to have seen several about the porch of the house, but they invariably made their escape, just to give mother the shivers as she recalled grandmother's experience of long ago. Mother would on these occasions declare that I let the snake get away on purpose, but who ever heard of a boy permitting a snake to escape if he could prevent it?

Ophibolus doliatus triangulus (Boie.) is also known as the milk-snake, although it most likely cares no more for milk than would any other thirsty ophidian; but because it frequents spring houses, in which milk is kept, to catch frogs and salamanders which live in these cool places, the owner of the milk could not resist the temptation to give it a new name. Another of its many



THE MILK-SNAKE.

local names is "thunder-and-lightning snake," but I cannot imagine why so gentle a serpent should be so named. It is perfectly harmless. Recently I saw a frightened specimen bite a school-girl, but she only laughed. An uncle of mine once caught a house-snake lying on a shelf in his store. Knowing its value he placed it in his corn-crib, where it remained all summer. It is needless to say that the mice quickly disappeared. Besides mice and rats the house-snake catches many

THE SNAKE CLIMBING A TREE.

crickets, grasshoppers, cockroaches and other insects. It is very beneficial to the farmer and should never be killed.

It varies much in color but the markings are very distinct. Gray or silvery bands and reddish-brown blotches mark the back, while beneath it is checkered with black and yellowish-white, making this a handsome reptile. Frequently when disturbed it sets its short tail vibrating as many other snakes do when angry. It is an expert climber, but seldom climbs trees, preferring to creep about old houses and barns. On one occasion I knew of one climbing up a small tree a few feet to a bird's nest.

Those who care to handle reptiles will find the house-snake an interesting pet. It sometimes reaches a length of four feet; specimens ordinarily, however, are less than three feet. The young are hatched from eggs.

ARTHUR RUSMISELLE MILLER SPAID.

THE GIANT FISHES OF THE SEA

MANY people, including some scientists, believe that there exist in the sea to-day monster animals —sea-serpents, leviathans, and giant fishes—

A MAN-EATER SHARK IN THE WAKE OF A VESSEL.
(It is about forty feet long when full-grown.)

which have never been captured, and hence are unknown to zoölogists and have no place in scientific books. Whatever may be the facts in regard to such creatures, there are well-known members of the fish class which deserve to be regarded as monsters, and which may have given rise to the sea-serpent stories. Some of the most noteworthy of these fishes are here referred to and illustrated.

At the mention of giant fishes, many young folk will at once think of the sharks, among which, indeed, are found the largest existing fishes. Of the numerous kinds of sharks noteworthy on account of their size, there are four in the front rank; these are the sleeper-shark, the man-eater shark, the basking-shark, and the whale-shark.

The sleeper-shark, whose scientific name (*Somniosus microcephalus,* meaning sleepy small-headed fish) fits it so admirably, appears to have developed its body at the expense of its brain, for it is a sluggish, stupid glutton, about six times as long as the average man. Its home is in the arctic regions, but it sometimes makes visits as far south as Massachusetts, Oregon, and the British Isles. It is usually seen lying quietly at the surface, apparently dozing, and is easily approached by vessels; but sometimes, when hungry, it rouses itself and goes in search of its prey, fiercely attacking and injuring whales, apparently unconscious of the great difference in their respective sizes.

One of the largest, and perhaps the most formidable, of sharks is the "man-eater," or great blue shark (*Carcharodon carcharias*). It roams through all temperate and tropical seas, and is everywhere dreaded. Its maximum length is forty feet, and its teeth are three inches long. While there are few authentic records of sharks attacking human beings, there have undoubtedly been many cases of sharks simply swallowing people who have fallen overboard, just as they would swallow any other food. How easy it would be for a man-eater to devour a person, may be judged from the finding of a whole hundred-pound sea-lion in the stomach of a thirty-foot shark on the California coast. A certain man-eater, thirty-six and a half feet long, had jaws twenty inches wide inside, and teeth two and a half inches long.

The basking-shark, known also as the elephant-shark and bone-shark (*Cetorhinus maximus*), is an inhabitant of the polar seas, but is occasionally observed as far south as Virginia and California, and some years ago was not rare on the English and New England coasts. It reaches a maximum length of fifty feet, and is exceeded in size by only three or four animals now alive. Provided with small teeth, it feeds on fishes and floating crustaceans, and is not of a ferocious disposition. It is dangerous only because of its great bulk, and when attacked its powerful tail easily demolishes small boats. The basking-shark was formerly hunted on the coasts of Norway and Ireland for its oil; it was also sought on the shores of Massachusetts in the early part of the last century; and many of these sharks from twenty-five to thirty-eight feet long were recorded. The liver of a large specimen sometimes yielded twelve barrels of oil.

A SAWFISH ENTANGLED IN A NET.
(This fish is about twenty feet long when full-grown.)

OCEAN SUNFISH SUNNING THEMSELVES.
(They are about eight feet long when full-grown.)

The largest of all fishes, the largest of all cold-blooded animals, and the largest of all existing animals, except a few kinds of whales, is the whale-shark (*Rhineodon typicus*), originally discovered at the Cape of Good Hope, but now known in Japan, India, South America, Panama, California, and elsewhere, a specimen having recently been obtained in Florida. This shark is said to attain a length of seventy feet, and is known to exceed fifty feet.

A fish of such peculiar form that the Italians call it *mola* (millstone), and the Spaniards *pez luna* (moonfish), is known to Americans and English as the sunfish, for it appears at the surface of the ocean on bright days and spends many hours basking listlessly in the sun, sometimes lying flat with one side out of the water, sometimes with the back fin projecting like a buoy above the surface. The fish is disk-shaped, its height nearly equaling its length. It is one of the most grotesque of fishes, being apparently nearly all head. Of almost world-wide distribution, it is particularly abundant on the southeastern coast of the United States and on the California coast. It swims but little, being usually content to be drifted along by the ocean currents. The Gulf Stream wafts many a sunfish north each summer, so that the species is not rare off southern New England. That the fish deserves a place on the list of giant fishes may be judged from the fact that examples weighing from two hundred to five hundred pounds are not rare, and that much larger ones are occasionally met with. The weight of the largest known specimen, caught in 1893, at Redondo Beach, California, was eighteen hundred pounds. On such a monster, lying on its side, there would be room for thirty men to stand.

In the lagoons, sounds, and bayous of the West Indies and our southern coast, there exists in abundance a fish of great length, called the sawfish. The species is well known to those who reside on or visit the South Atlantic and Gulf seaboards, and the "saws" are familiar objects in "curio" stores all over the country. This fish has a broad, depressed body, and its greatest length exceeds twenty feet. The largest examples have saws six feet long, and a foot wide at the base, with teeth several inches long. The sawfish is without commercial value, and is never sought, but it has a way of getting entangled in the fishermen's nets and badly damaging them in its struggles to escape, so that the fishermen regard it as a nuisance, and have to handle it with care in order to avoid the serious injury that might be inflicted by a lateral sweep of a big fish's saw.

The valuable mackerel family has one member which easily ranks first in size among the "bony fishes," as distinguished from the sharks, rays, sturgeons, etc., which have gristly skeletons; this is the horse-mackerel, or great tunny (*Thunnus thynnus*), whose range encircles the globe, and which is an object of fisheries in many countries, notably southern Europe. Built on the compact and graceful lines of our common mackerel, it

A HORSE-MACKEREL, OR GREAT TUNNY, CHASING MENHADEN.
(The great tunny is about fifteen feet in length when full-grown.)

GIANT RAYS, OR DEVIL-FISHES.
(They are about twenty-five feet wide when full-grown.)

excels in speed, alertness, and vigor among the fishes of the high seas, and might very easily make a trip across the ocean in one third the time of our fastest steamships. It preys on all kinds of small fish, and is often seen playing havoc among schools of luckless herring and menhaden. Fifteen feet is about its maximum length, and fifteen hundred pounds its estimated maximum weight, although it is likely that this weight is considerably exceeded. Thirty tunnies harpooned by one fisherman during a single season weighed upward of thirty thousand pounds. A mutilated specimen ten feet long was found by the writer on the coast of Massachusetts; its head weighed two hundred and eighty-two pounds; its carcass about twelve hundred pounds.

Among the rays are several members which reach colossal proportions. The largest and best known of these is the so-called "devil-fish" (*Manta birostris*) of our South Atlantic coast and the tropical waters of America. It occasionally strays as far north as Cape May, and is common south of Cape Hatteras. It is shaped like a butterfly or bat, and has been called the "ocean vampire." Projecting from either side of the head is a horn-like appendage, which, in reality, is a detached part of the pectoral fin, or "wing"; these horns, to which the name "devil-fish" owes its origin, are sometimes three feet long, and are movable, being used for bringing food to the mouth. Many years ago, the pursuit of this fish was a favorite pastime of the Carolina planters; and William Elliott, in his "Carolina Sports by Land and Water," says: "Imagine a monster from sixteen to twenty feet across the back, full three feet in depth, possessed of powerful yet flexible flaps or wings, with which he drives himself furiously in the water, or vaults high in the air." There are well-authenticated instances of this fish entangling its horns in the anchor-ropes of small vessels and towing the vessels rapidly for long distances, to the mystification of the people on board. The expanse of body is greater in this species than in any other known animal. Examples sixteen feet wide are common, and those twenty feet across and over four feet thick are not rare. The maximum width is stated by authors to be from twenty-five to thirty feet. One specimen, of which the writer has a photograph, caught in Lapaz Bay, Mexico, many years ago, by the crew of the U. S. S. *Narragansett,* of which Admiral Dewey was then captain, was seventeen feet wide and weighed nearly two tons. A fish of the largest size mentioned would weigh not less than six tons.

Hugh M. Smith.

THE TUATERA

Tuateras are a curious species of the lizard tribe, which exists only in New Zealand, and then only in some parts of that country, as Stevens Island in Cook Strait.

An authority on tuateras says: "I once had two, many years ago, who appeared to live happily for a couple of months on the 'light of other days'; for they ate nothing—they sometimes would not move for a day or two."

The most curious thing about them is that they have helped explain the existence of a certain gland that we have in our heads. The tuatera has the same gland, only in a far more developed state; and this gland is "the nearest approach to a third or pineal eye of any known animal; in fact, the eye is fairly developed, but is hidden under the skin between the eyes they use for every-day use." Tuateras are of a brown color, with tiny white spots all over them, the spots being larger and whiter on the throat and stomach; they enjoy burrowing into the earth, also basking in the sun and catching flies. The word comes from *tua,* the back, and *tara,* a spine, that is, spiny-back.

THE LARGEST ANIMALS

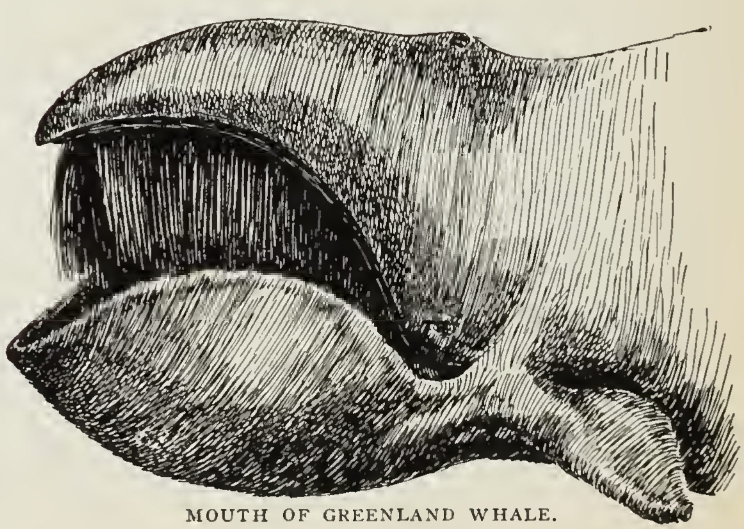
The lighthouse-keeper's little daughter carrying dinner to her father in the lighthouse. She sees a drove of whales "spouting" near to the shore and points them out to her dog.

Roaming singly or in "droves" through all the oceans, from the tropics to the poles, are many kinds of immense creatures, fish-like in shape and popularly regarded as fishes, but hot-blooded, air-breathing, and having little in common with fishes except the element in which they live. These, the whales, dolphins, grampuses, and their tribe, called collectively cetaceans, are the real monarchs of the seas, and in size and length surpass any other animals of either land or water which now exist, or which are known to have lived in ancient times. From a very early period whales have been hunted by man, and they have added more to the wealth and prosperity of the civilized world than any other group of wild warm-blooded animals.

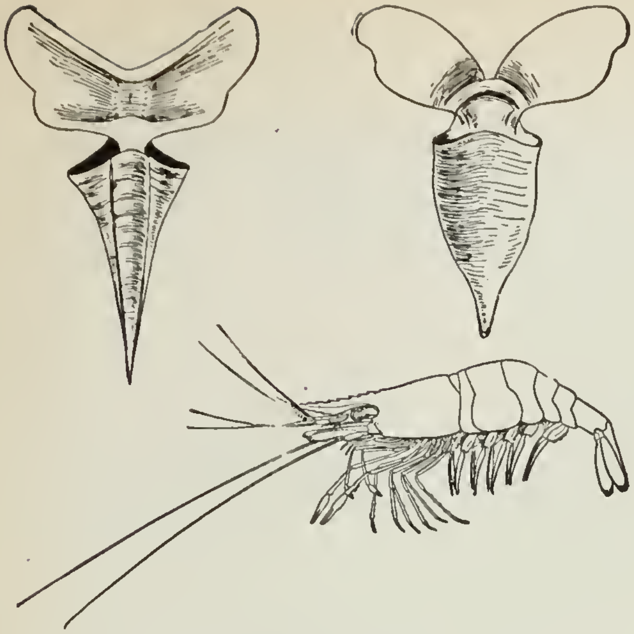
In order that they may keep warm, whales are completely incased in a thick layer of fat or blubber, from which is made the whale oil of commerce. In former years it was profitable to hunt whales for this oil, but petroleum and fish oils have to a great extent replaced whale oil and have so reduced its market value that whales would now rarely be killed by man if they did not yield several more important products.

One group of whales have teeth in the lower jaw but none in the upper jaw. The largest and most valuable of these toothed whales is the sperm-whale, or cachalot, which has a head of strange shape and with strange contents. The lower jaw is long and narrow, and has a row of large conical teeth placed far apart; and it is so loosely joined to the skull that in feeding it may be dropped to an almost vertical position and also swayed from side to side. The upper part of the head is an immense straight-sided mass, with the blow-hole or nostril at the top of the flat nose. In the head is a natural oil-well—a large cavity filled with sperm-oil, of which more than twenty-five barrels have been taken from a single whale.

The sperm-whales sometimes reach a length of eighty-five feet, and those seventy feet long are not uncommon. They go in schools which may contain hundreds of individuals, and are found in all parts of the world except the polar regions. They feed mostly on squids, cuttle-fish, and devil-fish, and they are able to destroy the largest of these animals.

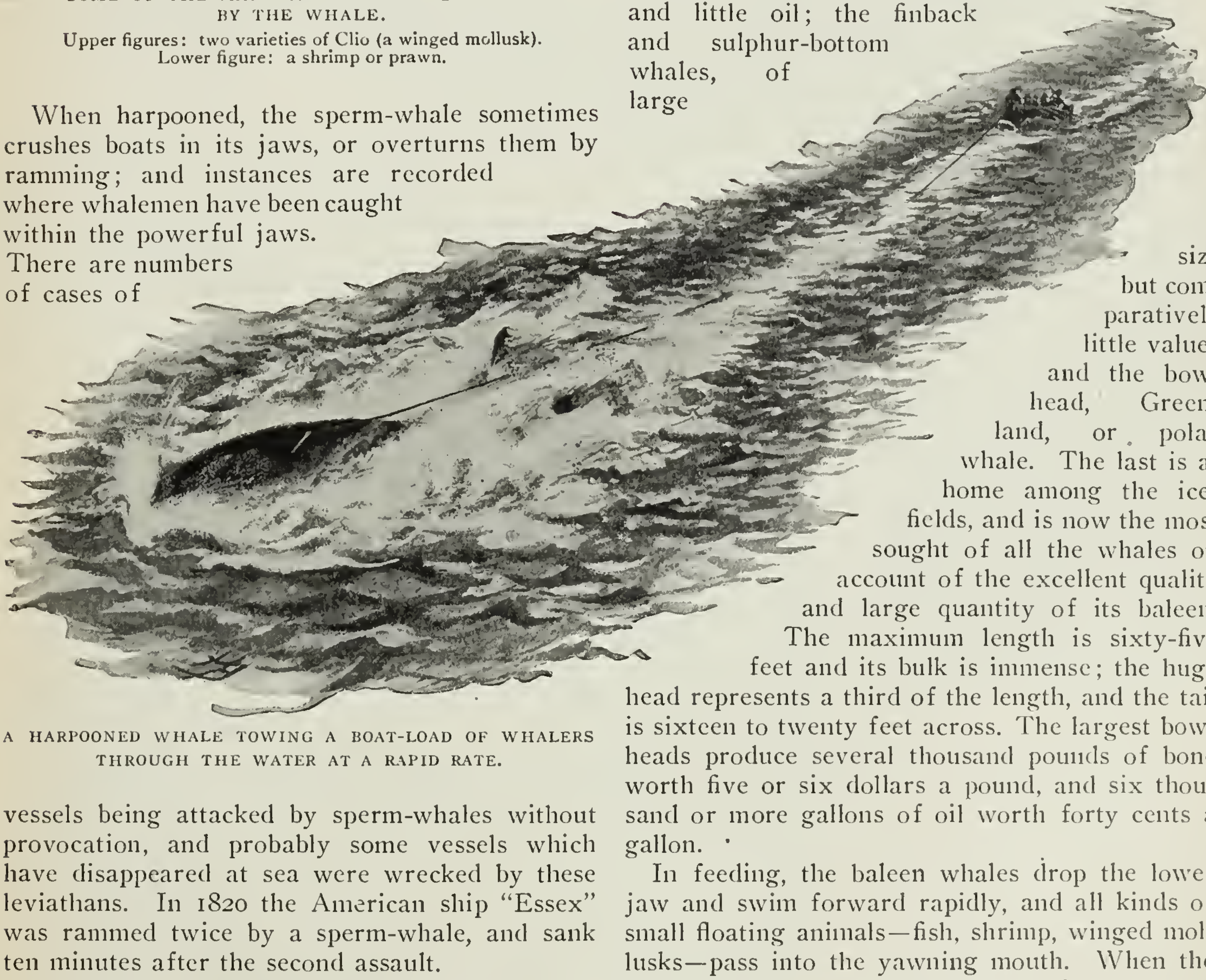


MOUTH OF GREENLAND WHALE.
Showing strainers (baleen).



SOME OF THE MANY SMALL ANIMALS EATEN BY THE WHALE.
Upper figures: two varieties of Clio (a winged mollusk). Lower figure: a shrimp or prawn.

When harpooned, the sperm-whale sometimes crushes boats in its jaws, or overturns them by ramming; and instances are recorded where whalemen have been caught within the powerful jaws. There are numbers of cases of



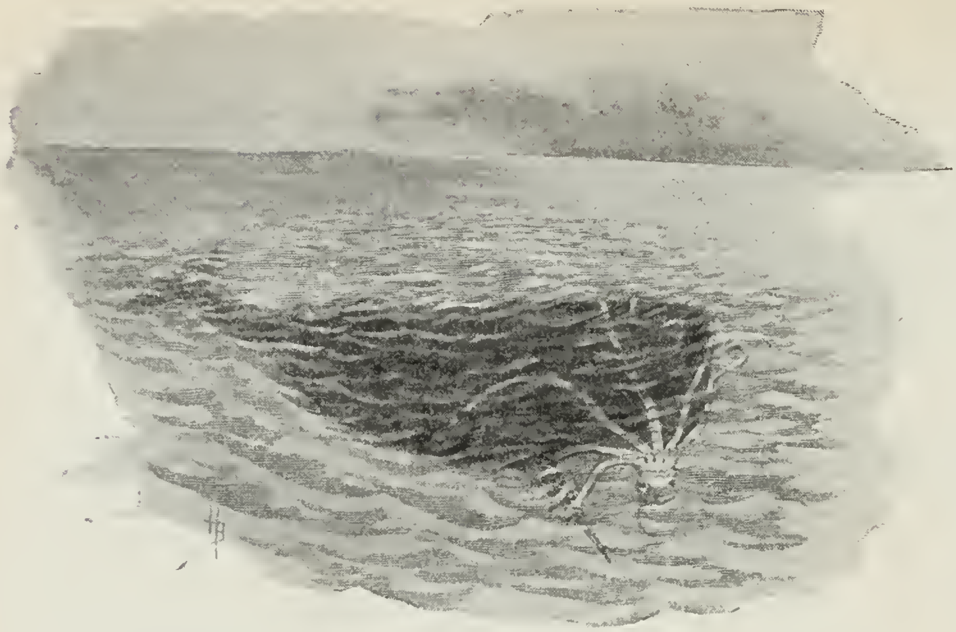
A HARPOONED WHALE TOWING A BOAT-LOAD OF WHALERS THROUGH THE WATER AT A RAPID RATE.

vessels being attacked by sperm-whales without provocation, and probably some vessels which have disappeared at sea were wrecked by these leviathans. In 1820 the American ship "Essex" was rammed twice by a sperm-whale, and sank ten minutes after the second assault.

Another group of whales have no teeth, but the mouth is provided with several hundred closely packed horny, flexible plates or slabs suspended from the roof of the mouth and hanging on each side like a curtain, so that when the mouth is opened as wide as possible their ends are received within the lower jaw. These plates, which in some whales are nine or ten feet long, have pointed, frayed extremities, and are lined with long, stiff hair. This peculiar substance in the mouth of whales, which is called baleen, or whalebone, although it is not bone, is now the most valuable product which is yielded by these creatures; and to obtain it thousands of men brave the dangers of the seas, of the arctic ice, and of the chase, killing the whales by hurling harpoons and shooting explosive bullets into them from a small boat.

Among the various kinds of whalebone-whales is the right whale, which reaches a length of sixty feet and yields two hundred barrels of oil and a thousand pounds of long, valuable baleen; the humpback whale, which is sometimes seventy-five feet long, but has short bone and little oil; the finback and sulphur-bottom whales, of large size but comparatively little value; and the bowhead, Greenland, or polar whale. The last is at home among the ice-fields, and is now the most sought of all the whales on account of the excellent quality and large quantity of its baleen. The maximum length is sixty-five feet and its bulk is immense; the huge head represents a third of the length, and the tail is sixteen to twenty feet across. The largest bowheads produce several thousand pounds of bone worth five or six dollars a pound, and six thousand or more gallons of oil worth forty cents a gallon.

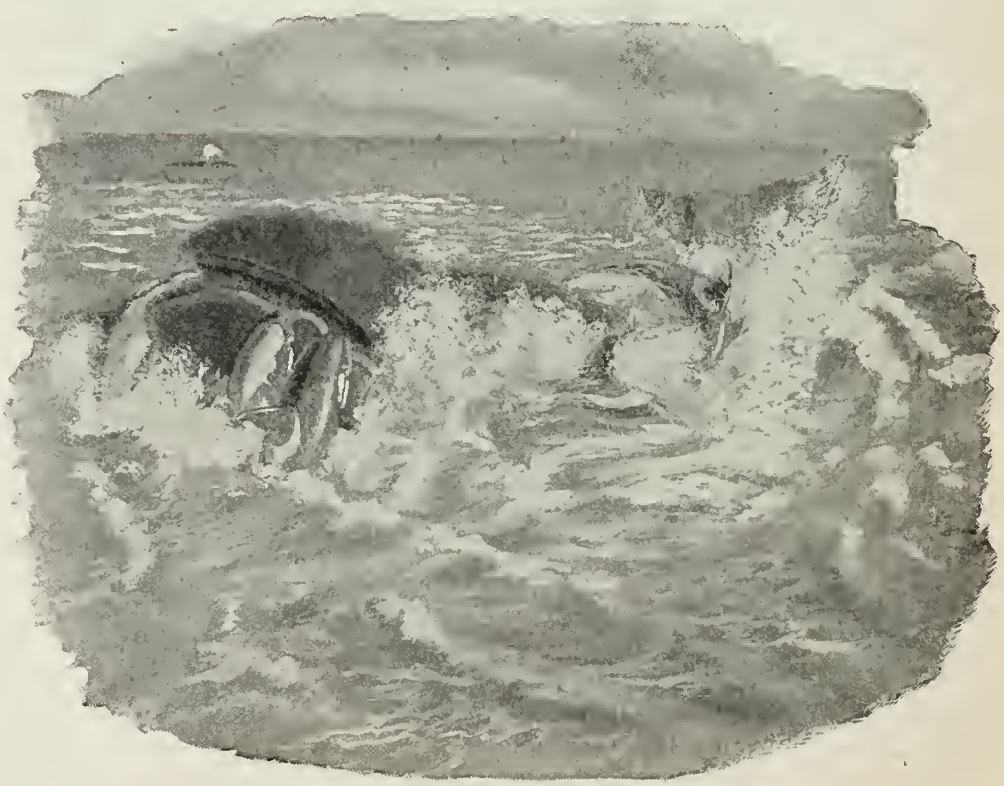
In feeding, the baleen whales drop the lower jaw and swim forward rapidly, and all kinds of small floating animals—fish, shrimp, winged mollusks—pass into the yawning mouth. When the lower jaw is closed, the plates of baleen are forced upward and backward, the water rushes through the sieve formed by the hairs, the food is left behind, and is swallowed by the aid of the tongue.



SPERM-WHALE DEVOURING A LARGE OCTOPUS.

Some of the baleen whales are said to attain a length of more than a hundred feet, and there are authentic records of examples measuring between ninety and a hundred feet. The largest species of whale, and therefore the largest of all living animals and the largest creature that ever existed, so far as we know, is the sulphur-bottom whale of the Pacific coast. One of these was ninety-five feet long and thirty-nine feet in circumference, and weighed by calculation nearly three hundred thousand pounds. The sulphur-bottom whale is further distinguished by being the swiftest of all whales and one of the most difficult to approach; it glides over the surface with great rapidity, often displaying its entire length; and when it respires the immense volume of vapor which it throws up to a great height is evidence of its colossal proportions.

On one occasion a sulphur-bottom whale remained with a ship for twenty-four days, often passing under it and touching the hull; although it was shot with rifle-balls and struck with logs of wood and other missiles, it refused to desert the vessel until it entered shallow water.



A DROVE OF ORCAS ATTACKING A BOWHEAD WHALE.

Most savage and powerful monsters are the orcas, or killer-whales, which, while comparatively small as whales, are so rapacious, active, and strong-jawed that no other animals, not even the fiercest of man-eater sharks and the largest of whales, can withstand their awful onslaughts. Favorite objects of their assaults are the toothless whales, and some of the bloodiest fights occur when mother whales are attacked while guarding their young. The orcas hunt in small droves, and are veritable ocean wolves, surrounding their prey, tearing great pieces from the lips and throat and biting out the tongue, the whales drowning, or dying from loss of blood.

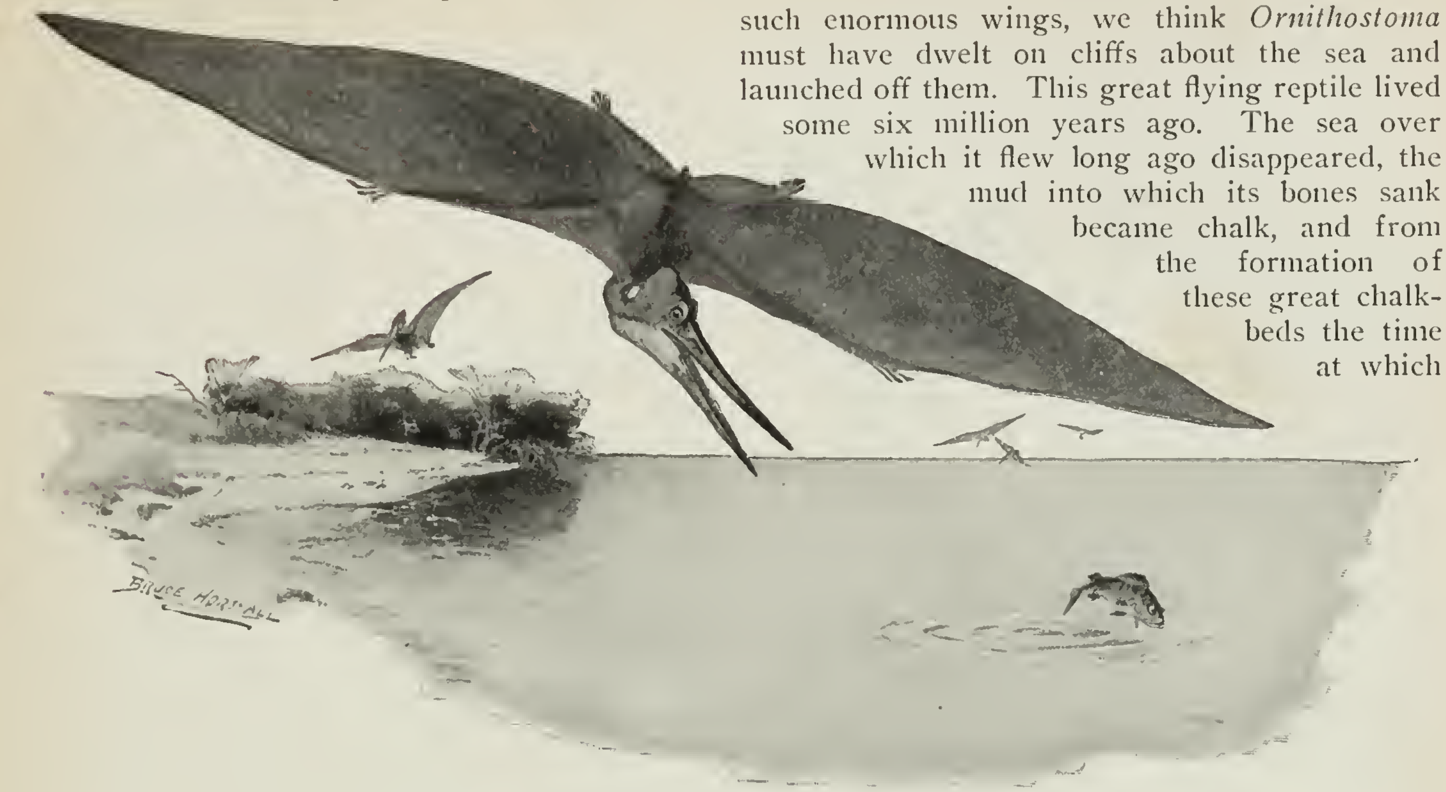
Hugh M. Smith.

THE LARGEST FLYING CREATURE

We are apt to think of reptiles as creeping and crawling things, forgetting that there was a time when flying reptiles were more common than birds. These reptiles, the pterodactyls, or flying dragons, not only flew, but some of them reached a size much greater than that of any bird, for the largest birds do not fly. The South American

condor sometimes measures as much as ten and one-half feet from tip to tip of outstretched wings, and it is quite possible that the finest examples of the albatross may measure a little more. But the great pterodactyls which flew about the sea that in the days of old reached from the Gulf of Mexico to the Rocky Mountains measured as much as twenty feet, the width of an average city lot, across their wings. Many of us have seen an eagle flying, and we can appreciate the size of this ancient dragon by remembering that it was nearly three times the size of an eagle. It was not, however, three times as heavy, for the body of this strange reptile was so small and its skeleton so wonderfully light that the entire animal is thought to have weighed not more than twenty-five pounds, or only about as much as a large condor. One of the largest bones of the wing, two feet long and two inches through, was, as Professor Williston tells us, no thicker than a sheet of blotting-paper, and the great head, with a beak over three feet long, was equally light. This great toothless beak is believed to have been used for snapping up fishes; and we can imagine this huge creature sailing swiftly over the sea, now and then swooping down to pick up a fish as deftly for all its size as a real swallow. But what did *Ornithostoma*—this is the creature's name—do with his wings and beak when he made an occasional visit to the land? One would think they must have been very much in his way, and that the animal was as awkward on the shore as he was graceful in the air. And how did he start to fly? With such enormous wings, we think *Ornithostoma* must have dwelt on cliffs about the sea and launched off them. This great flying reptile lived some six million years ago. The sea over which it flew long ago disappeared, the mud into which its bones sank became chalk, and from the formation of these great chalk-beds the time at which *Ornithostoma* existed is called the Cretaceous Period.

FREDERICK A. LUCAS.



THE ORNITHOSTOMA—THE LARGEST FLYING CREATURE.

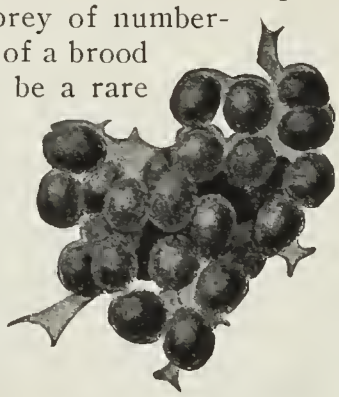
Of birds now in existence, probably the one with the greatest expanse of wing in proportion to the body, and with the greatest power of flight, is the frigate- or man-o'-war bird (*Fregata aquila*). This bird apparently flies more by skill than by strength, for it has no great carrying powers.

The wandering albatross, the largest of all sea-birds, is also one of our strongest fliers. One bird was known to fly at least 3150 miles in twelve days. This bird was caught, tagged, released, and caught again.

HOW THE LOBSTER GROWS

A LOBSTER lays thousands of eggs, most of which hatch, but few ever live to grow up. This is not the fault of the mother, for she carries them about with her for nearly a year, and with admirable instinct guards them as she does her own life. When the young are set free, her duty is done, for they must then shift for themselves. Though hardly larger than mosquitos, being about one third of an inch long, the little ones leave their parents on the bottom and swim to-

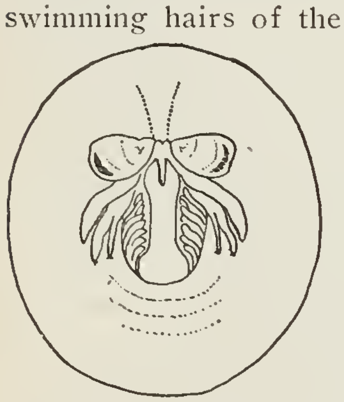
ward the light—to the surface, where, from one to two months, if fortune favors them, they lead a free, roving life. The open sea is a poor nursery for such weaklings, which become the sport of every storm and the prey of numberless hungry mouths. Out of a brood of ten thousand it would be a rare chance for more than one or two lobsters to reach maturity, or finally to end their career in the kitchen or the chafing-dish.



A CLUSTER OF LOBSTER EGGS.

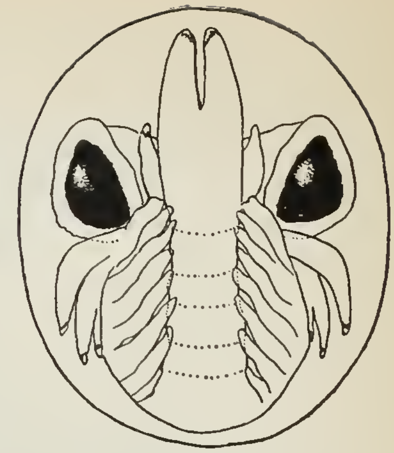
The eggs are commonly laid in midsummer—and but once in two years by the same individual—and are hatched in May or June. A "hen" lobster, eight inches long, will lay five thousand eggs; and the egg-producing ability grows apace, for at ten inches the average number is ten thousand, and for the sixteen-inch length nearly one hundred thousand. Each egg is a sphere of about the size represented by the capital O in this font of type (one sixteenth of an inch in diameter), of a deep olive color, and is inclosed in a transparent, waterproof sac, or shell, through which the eyes and other parts of the developing lobster can be watched. Not only are these thousands of delicate eggs nicely distributed over the under parts of the lobster's body, but all are glued to one another, or to the hairs of the swimming feet, with a kind of flexible hydraulic cement, which sets in the water, and holds the eggs fast.

You cannot help the young lobster out of his shell, but must let him escape in his own way, for hatching is a delicate process. His "swaddling clothes" must all come off together, that no energy be lost. The little lobster hatches, molts ("changes his coat"), and unsheathes the swimming hairs of his legs at the same time. The egg-shells stick to both mother and child, while the cuticle of the latter is in turn glued to the swimming hairs of the new skin, so that every tug at the shell helps to free the little lobster from the hampering cloak, and at the same time to perfect his swimming apparatus.



THE LITTLE LOBSTER AFTER 26 DAYS' GROWTH IN THE EGG.
(Diagram showing its form.)

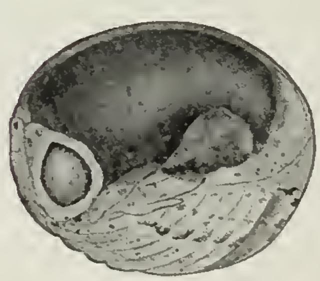
This coming from the shell and molting is always a serious business, and any hitch in the process is likely to prove fatal, especially in the early stages. In this critical act the entire shell, down to a microscopic hair, and everything derived from the external layer of the skin, or cuticle, including the lining of the stomach and the skeleton—for these parts are all formed from folds of the skin—are cast off in one piece. The whole process is dependent on growth, while this in turn is largely a question of age and of food. During the first year of life the lobster molts about seventeen times, but at its fifth year, when between ten and twelve inches long, not more than once or twice during that year.



THE BABY LOBSTER WITHIN ITS SHELL (61 DAYS OLD).

The black spots are the eyes, which develop very early and grow rapidly. Compare with sketch at bottom of first column.

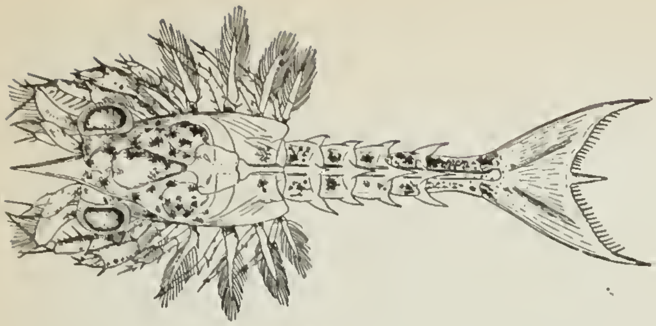
The young, at hatching, are equipped with peculiar swimming organs in the form of six pairs of "oars," each of which is the outer branch of one of the chewing, grasping, or swimming feet, and is fringed with long, feather-like hairs. The lobster can move forward in any direction by the rapid beating of these flexible oars, or spring backward by a sudden contraction of the tail. At birth the skin is clear as glass, and the colors, now a pale blue sprinkled with vermilion, increase in brilliancy up to the fourth or even to the sixth stage. The body is armed with spines, the most formidable of which, called the beak or rostrum, projects like a spear between the great stalked eyes. As a parting blessing from its parent, the lobster is started in life with provisions for its journey in the little store of yolk left over from the egg; but this is quickly absorbed, and the hungry larva soon begins to snap at floating particles of every kind—sand-grains, and scales of insects, as well as microscopic animals and plants which are its proper food. The young are also very pugnacious, and are cannibals to such a degree that it is almost impossible to rear them in small aquariums.



A SIDE VIEW OF A LOBSTER IN ITS SHELL.

As it is seen when looked at with a microscope through the clear shell.
The eye is the spot at the lower left. The large dark upper part represents the liver and stomach. The part shown as the clear spot at the right forms the heart.

In a few hours or days a second molt and then



THE LARVAL OR FIRST SWIMMING STAGE OF THE LOBSTER.

In this stage it has but little of the "lobster" form. It changes its coat (molts) rapidly as it grows and becomes more and more like the familiar lobster of the markets.

A LOBSTER IN THE FIFTH STAGE.

Becoming "lobster-like" in form. General color, reddish brown.

a third are passed, in the course of which, besides a general increase in size, many changes are to be noticed. At the fourth shedding of the skin they seem to pass with a sudden leap to the lobsterling stage, when both in form and habits they resemble an old lobster in miniature, being half an inch long; but they still keep at the surface. The fourth stage marks the turning-point in the lobster's career, and after one or two more molts it sinks to the bottom, never to rise again, unless cast up by the sea or drawn up in a fisherman's trap. Many, after reaching the bottom, move toward the shores and hide in piles of loose stone, from which they venture only to capture their prey, and then often at night. When four or five inches long they become bolder and swim farther out to sea, always of necessity keeping to the bottom. Some reach maturity when eight inches long and about three years old.

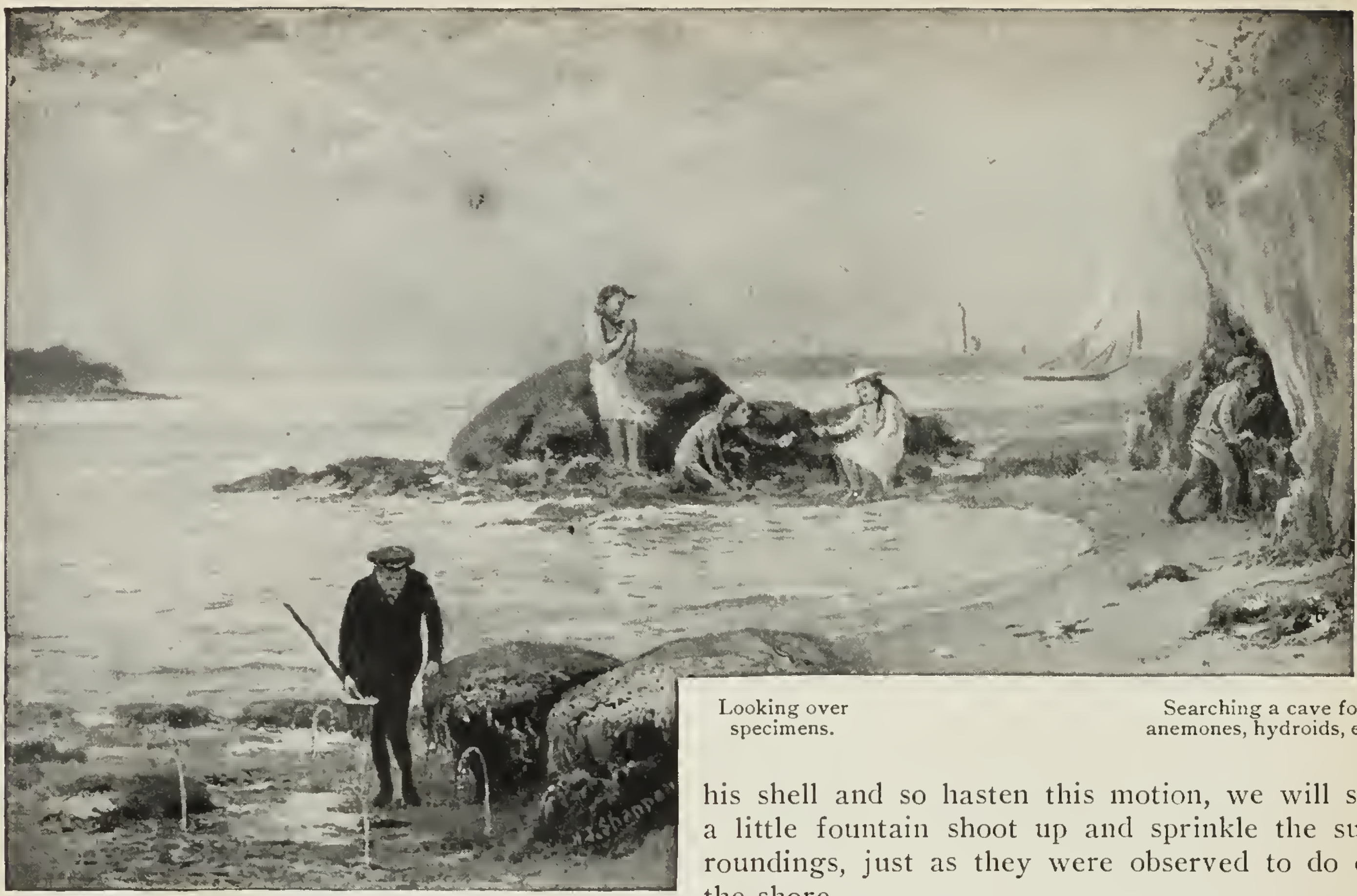
Francis H. Herrick,
Professor of Biology in Adelbert College
of Western Reserve University.

THE LIFE ALONG THE SEASHORE

As we walk along the shore at low tide, on the lookout for seaweeds or interesting animals, little jets of sea-water will be seen spurting up from holes in the sand. Let us dig rapidly down under one of these tiny openings and we will catch the spurter, the common soft clam; but if

THE FULL-GROWN LOBSTER AT HOME.

Among the rocks, loose stones, seaweed, and eel-grass. (Drawn from the live lobster in an aquarium representing the bottom of the sea.)

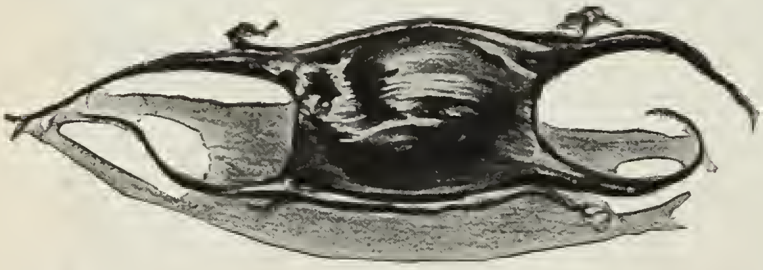


Looking over specimens.

Searching a cave for anemones, hydroids, etc.

Watching the spurtings of soft clams.

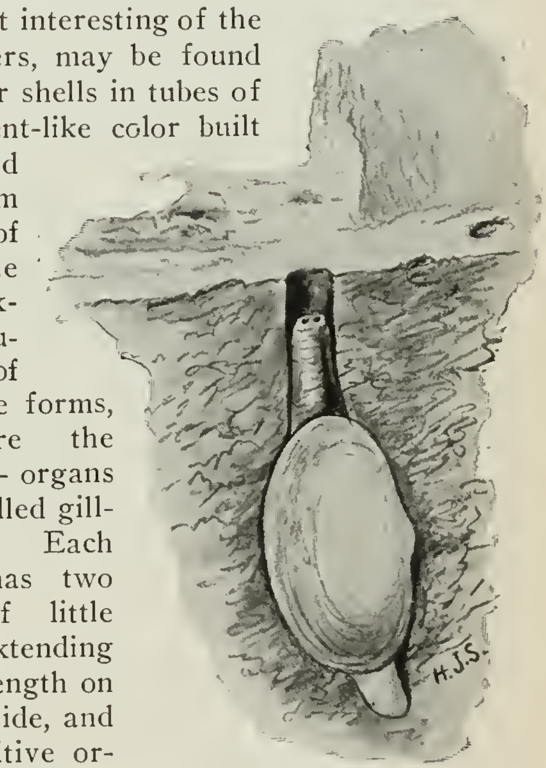
we are not quick enough he will burrow so rapidly as to disappear entirely and only send a last spout of water into our faces, as if in defiance. Place the shell in a glass of sea-water, and when the clam gains confidence he will extend from his shell the long tube-like siphon, and the two openings in the end of it, with their fringed borders, will be seen. Now take a compound microscope or a magnifying-glass and watch the water above the siphon. You will see that it is moving. With the minute life forms it contains, the water sweeps in swirling currents toward one orifice of the tube and plunges suddenly down it; then, after passing over the gills and body of the clam and giving out nourish-



AN EGG-CASE OF THE SKATE.

ment, the water is expelled through the other tube, and we see it rising slowly from the opening. If, however, the clam takes a fancy to contract his shell and so hasten this motion, we will see a little fountain shoot up and sprinkle the surroundings, just as they were observed to do on the shore.

Be sure to look for the many worms that may be found, either in burrows in the sand or in tubes which they have built on rocks and stones. All are interesting, and the forms and colorings of many are most beautiful, and their habits are remarkable. The sabella, one of the most interesting of the tube-builders, may be found on rocks or shells in tubes of a parchment-like color built of sand and mud. From the end of the tube the worm extends a plumy crest of feather-like forms, which are the breathing - organs and are called gill-filaments. Each filament has two fringes of little tentacles extending along its length on the inner side, and these sensitive organs come into play when the tube is



A SOFT CLAM BURIED IN THE MUD.
The siphon extended above and the foot burrowing below.

built. The process is wonderful. Bending down with slow and graceful motion, the worm allows

A CLAM PLACED IN A GLASS OF SEA-WATER.
Currents of water being watched through a magnifying-glass.

the fringes of the filaments to gather a portion of mud from the sea-bottom, when, fingering and molding it, the fringes carry it down the length of the filament to the bottom of the funnel. Here it is given into the charge of two leaf-like organs on the neck of the worm, which place this building-material on the edge of the tube and shape it there, while at the same time a mucous secretion is given off by the worm which gives the mud cohesive power. When the action ceases, it will be seen that the tube is slightly lengthened.

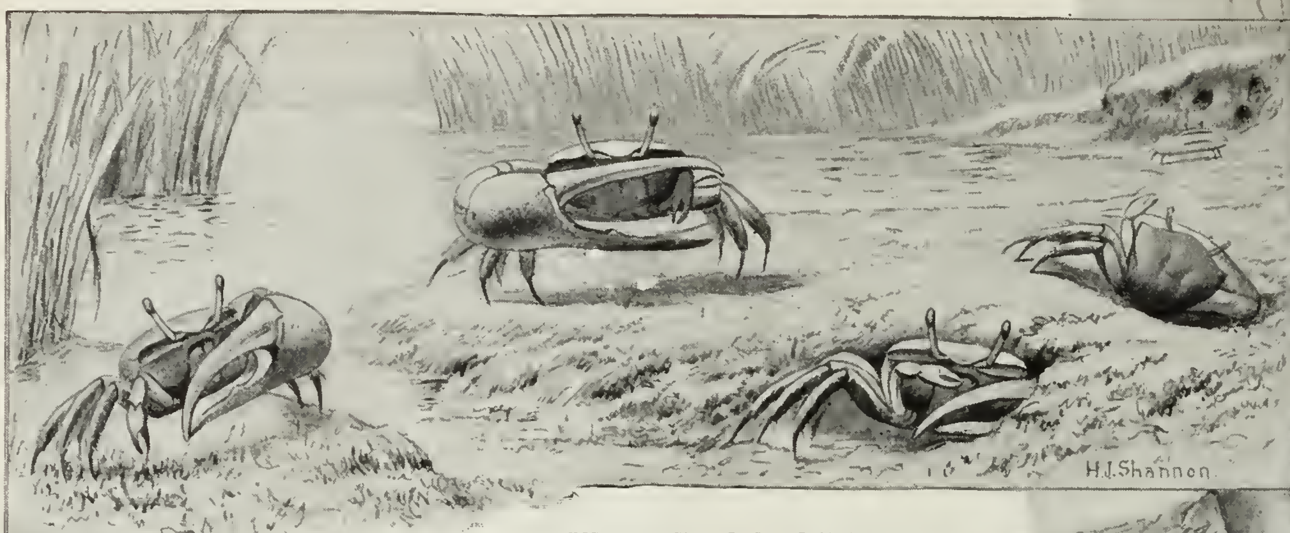
One of the most interesting members of the crab family is the queer and grotesque little "fiddler" which lives in burrows in the banks of

THE WORMS SABELLA LIVING IN THEIR TUBES ON AN OYSTER.
The worm at the right is not yet inclosed in the tube. There are some old abandoned tubes on the upper part of the oyster-shell.

creeks and estuaries back of the beach. Into these burrows the crab retires in autumn and composes itself for a long winter sleep. The eye-stalks are then folded down into sockets beneath the shell, and the large claw rests closed and inert against the body, while the legs are folded up until the entire animal is snugly closed upon itself, and it remains in this dormant condition until the spring. Early in April the fiddlers awaken, and immediately attend to clearing out their burrows. The large claw is useless for eating, only the small one being available for this purpose. It is amusing to see the delicacy with which this little claw feels about and picks up the particles of vegetable matter and places them in the

TWO BLUE CRABS FIGHTING.
Just in front of the crab coming toward us there is an anemone which has closed to protect itself. Expanded anemones are seen in the foreground at the left and on the rocks at the right. A hermit-crab and a shrimp are shown at the left.

mouth, while the eyes are all the time raised aloft on their stalks and apparently looking off into the distance. The female crabs have both



FIDDLER-CRABS IN SUMMER.

The one at the left is picking up food, while the one in the burrow is placing food in its mouth. At the extreme lower right a bank is shown as it appears in winter, cut through to show a crab hibernating in its burrow.

claws small and of equal size, so they are both used in feeding, and she can satisfy her hunger just twice as easily and quickly as the male. These fiddler-crabs also gather food and store it in their burrows for future use.

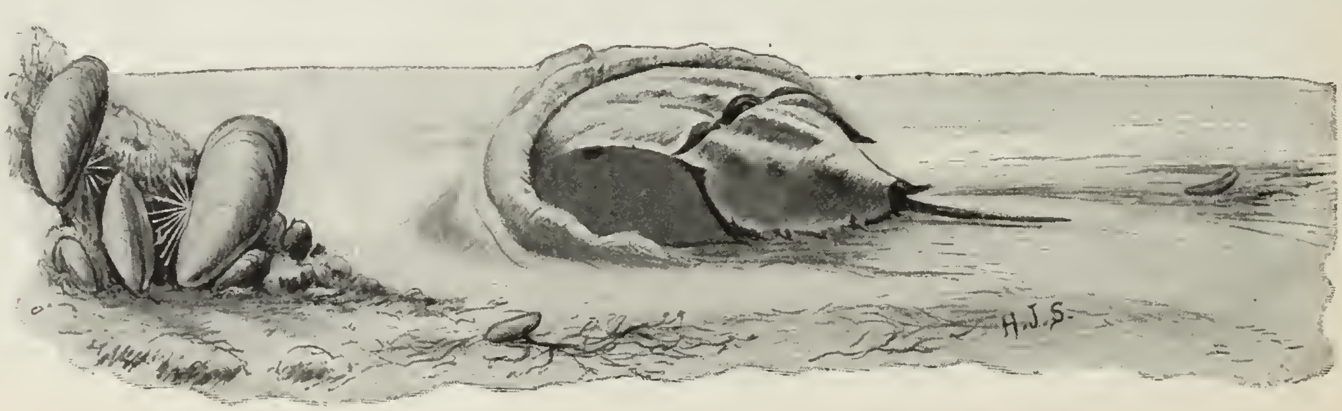
Another queer crab is the *Limulus polyphemus,* or horseshoe-crab. These crabs lay their eggs in the warm sand in summer, and in August the little ones hatch out in great numbers, so that in certain situations the shore is fairly alive with them. We may see them now, no larger than one's finger-nail, swimming actively about in the shallow water, or plowing the sand up before them with their queer little shovel-shaped heads. They soon retire to deep water and live there with their parents, either on the sea-bottom or half buried in the mud and sand.

Great quantities of mussels are fastened all along banks and on the rocks. If we try to pull one away, we find it is securely fastened by a bundle of mooring-threads called the byssus. The mussel produces these threads at will when it finds a suitable situation; and although of apparent delicacy, these strands are very strong.

HOWARD J. SHANNON.

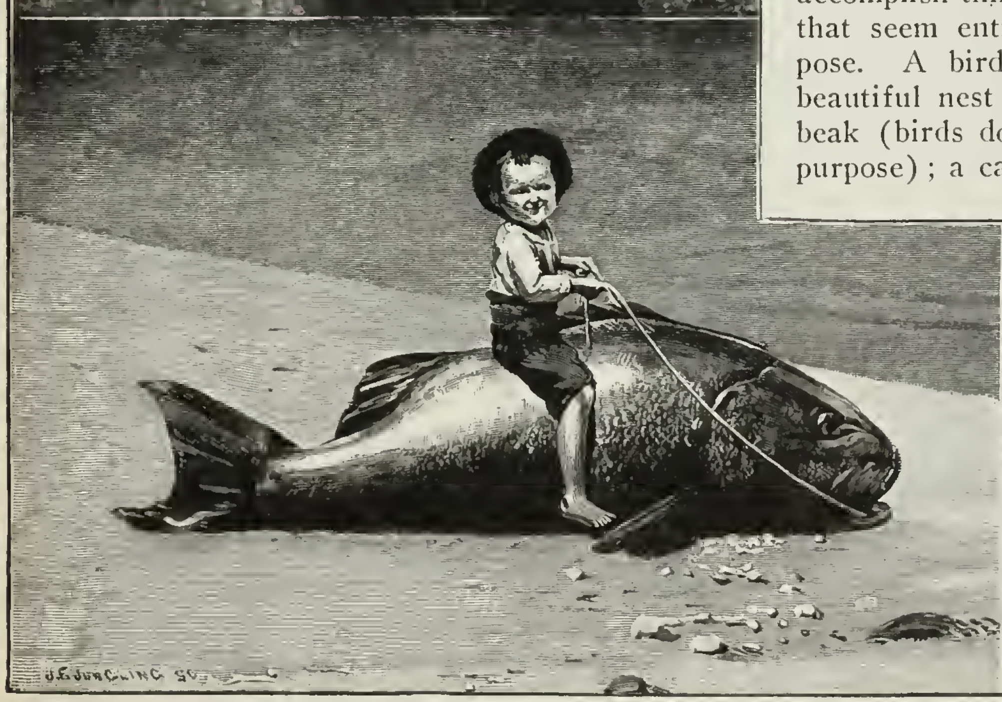
A MONSTER FISH

In this article we show a picture of a huge fish remarkable both on account of its size and its game qualities. It is known as the black sea-bass or California jewfish (*Stereolepis gigas*), and is found in moderate depths of the Pacific Ocean from the Farallones southward, being quite abundant in the kelp-beds about the islands off the coast. The one here shown was taken at Avalon, Santa Catalina Island, where anglers for large game-fish resort. The weight of the monster was four hundred and fifty-nine pounds. The fish is said to attain a weight of six hun-



A HORSESHOE-CRAB BURROWING ON THE BEACH.

At the left some mussels are attached to the bank by their anchoring-threads.



"A LITTLE FELLOW WAS PLACED ASTRIDE THE MONSTER AND PHOTOGRAPHED."

dred pounds or more. It feeds chiefly on other fishes, and, taken by hook and line, affords great sport for anglers. Heavy (25-ounce) 7½-foot rods of green-heart or split bamboo, large and well-constructed reels with a capacity of four hundred feet of No. 21 Irish-linen line, a 9-foot wire leader, and a 10-inch hook baited with several pounds of albacore, barracuda, or a live white-fish (*Caulolatilus*), are the tackle used by sportsmen. Rope, chain for leaders, and shark-hooks are used by the native hand-line or market fishermen.

The black sea-bass of California is one of the groupers, several of which grow to a weight of five hundred pounds or more (for example, the guasa, or spotted jewfish, and the black grouper).

Two notable specimens taken by rod and line weighed, one 419 and the other 384 pounds.

C. F. Holder tells us of a huge jewfish which he caught. It measured six feet in length and weighed three hundred pounds. He says:

"After we had beached the fish, a little fellow, who had been heard to say that he would like to ride a real jewfish, was placed astride the monster and was photographed."

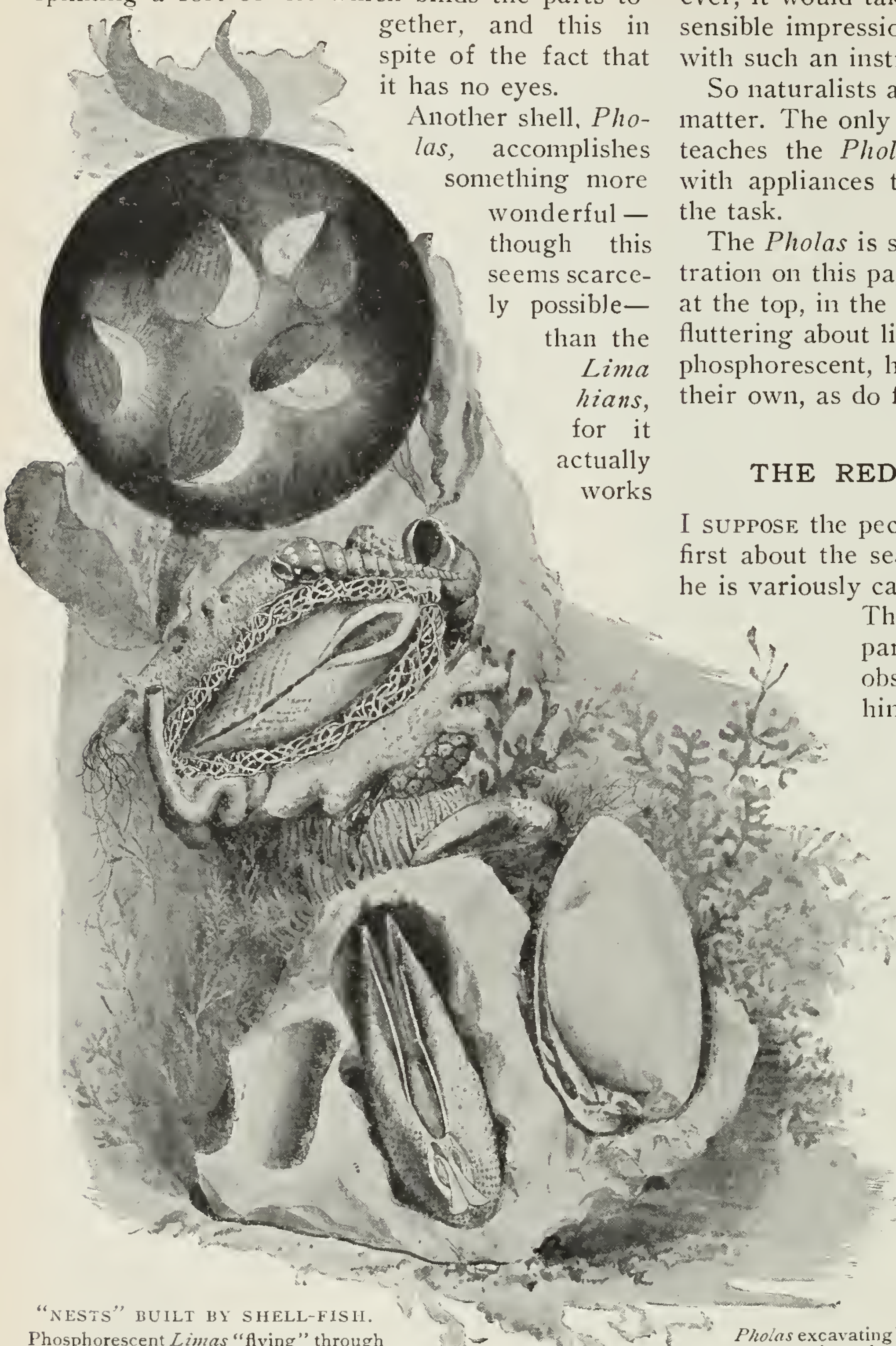
WONDERFUL WORK BY SHELL-ANIMALS

One of the most wonderful things Mother Nature does is to teach her children how to accomplish things with means and appliances that seem entirely inadequate for the purpose. A bird will build an intricate and beautiful nest with no better tool than her beak (birds do not use their claws for this purpose); a caterpillar can shape a symmetrical cocoon, and bees the sharp-angled cells of their combs. These are familiar instances of this, but by no means as wonderful as those shown in the work of some sea-animals that live in shells.

A certain sea-shell, *Lima hians,* shown in the illustration snugly ensconced in a dainty little nest of pretty variegated, tiny shells and red coralline, not only swims about as freely as a butterfly flies—though, as far as its form is concerned,

a snuff-box would be apparently as well fitted to do so—but actually builds the nest that it lives in, spinning a sort of net which binds the parts together, and this in spite of the fact that it has no eyes.

Another shell, *Pholas,* accomplishes something more wonderful—though this seems scarcely possible—than the *Lima hians,* for it actually works



"NESTS" BUILT BY SHELL-FISH.
Phosphorescent *Limas* "flying" through the water as butterflies through the air.

Pholas excavating burrows in rocks.

out nests or burrows for itself in the hardest sort of rocks, such as gneiss and granite. No one knows how this is done, for the material of the shell and of every part of the animal inside of the shell is, of course, much softer than the rocks into which it burrows. It is generally supposed that the creature works its way into the hard substances that it penetrates by means of what is called its foot, which is covered with a hard armor that is said to be renewed as soon as it is worn away. As may be conjectured, however, it would take a very long time to make any sensible impression on the hard gneiss or granite with such an instrument.

So naturalists are not all of one mind about the matter. The only certainty is that Mother Nature teaches the *Pholas* to do this marvelous thing with appliances that seem utterly inadequate to the task.

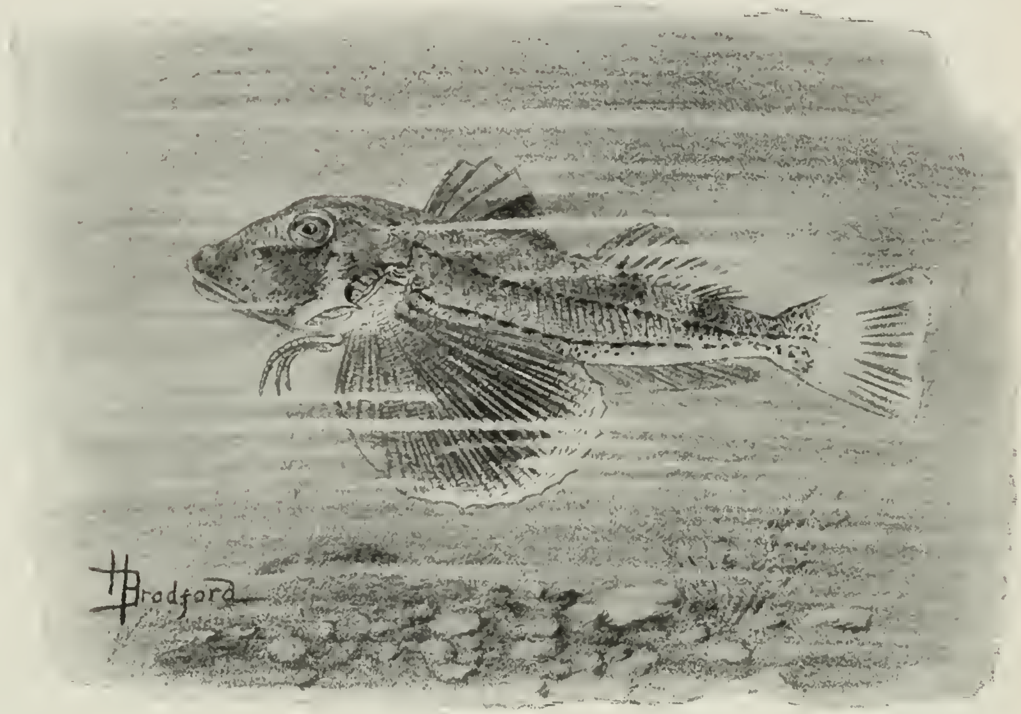
The *Pholas* is shown at the bottom of the illustration on this page, safe within its rocky "nest"; at the top, in the circle, are to be seen the *Limas,* fluttering about like moths in the dark. They are phosphorescent, however, and give out a light of their own, as do fireflies.

THE RED-WINGED SEA-ROBIN

I SUPPOSE the peculiarity which would be noticed first about the sea-robin, grunter, or gurnard, as he is variously called, would be his clumsy shape. The head is large and deep in comparison with the body. One of our observing young folks, looking at him alive in his tank of the United States Fish Commission, Washington, would be apt to exclaim, "Oh, see, he has little hook-claws which help him crawl along!" Sure enough, just in front of the pectoral or side fins are three little, finger-like processes on each side, which are used to stir up weeds and sand, and to rake around among the pebbles and rout out the small animals upon which the sea-robin feeds in its native waters. While doing this it seems to be crawling along over the bottom by hooking these peculiar claws into the sand. Sea-robins feed on small crabs, fish, shrimps, and other diminutive animals, which they find in among the loose stones. In Europe all the gurnard family of fishes are eagerly sought, as they find a ready sale in the fish-market. They attain a length of two feet and a weight of eleven pounds. Our species of the sea-robin, a cousin to the European variety, is found on our northern coast, and is taken in great numbers in the pound-nets along Vineyard Sound, where they spawn in the summer.

They are much esteemed for the table, being one of the most delicate of the edible fishes. The flesh is firm, snow-white, and hard to distinguish from that of the kingfish. The American sea-robin is fifteen to eighteen inches long and weighs from one and one fourth to two pounds. When taken from the water they grunt quite loudly, and if placed on the ground give a little hop forward of a few inches, grunting as they do so. This grunting sound can be heard quite plainly if one is in a boat lying quietly in shallow water near where they are.

The head is sheathed with bony plates and armed with sharp points, which are rather hard to distinguish at first, as they lie quite flat against it. When caught they erect all their spines and inflict very painful wounds on those who try to handle them. The pectoral fins are a little more than half as long as the body, and may be extended like a fan when in use, or folded quite close together when on the bottom, thus giving them the name of "butterfly-fish."



THE RED-WINGED SEA-ROBIN.

The "hook-claws" are placed quite close to the body when the fish moves very fast, and are thus hidden by the large pectoral fin. But when near the ground they are extended in anticipation of clutching the sand or stony bottom. The artist has represented the fish quite near the bottom, in which case the claws are shown in the drawing.

The rays of the tail may also be much extended to look like a Japanese fan.

The color of this peculiar fish is a brownish yellow over the back and sides and cream-white below. The pectoral fins are deep orange-color with a blackish marking toward the tips, crossed all over with little dark brown lines and edged with light yellow-orange color. The lower jaw and sides are light orange-yellow; the eye is a beautiful turquoise-blue, edged with a vein of brassy yellow. HARRY B. BRADFORD.

THE MUSSEL'S MUSCLE, AND HOW HE USES IT

How is it that a mussel can close its shell so forcibly? The muscles are two in number, one in each end of the shell. They extend straight across from one valve to the other. Thus the fibers act at no disadvantage. The muscles in the arm of a man are arranged at great disadvantage, power being sacrificed for amount and rapidity of motion.

You must, sometime, try to open the shell of a fresh-water mussel or a sea-clam. You will find one the size of your hand has great strength, although both his muscles may not be larger than those of one of your fingers. We have often seen a boy pick up a mussel and insert his fingers before the shell was quite closed, thinking he could open it again. Few boys can succeed. They usually have hard pulling to get their fingers free. A big mussel can bite hard. Were it not that the edge of the shell, in big specimens, is smooth and thick, a boy might get his fingers cut to the bone.

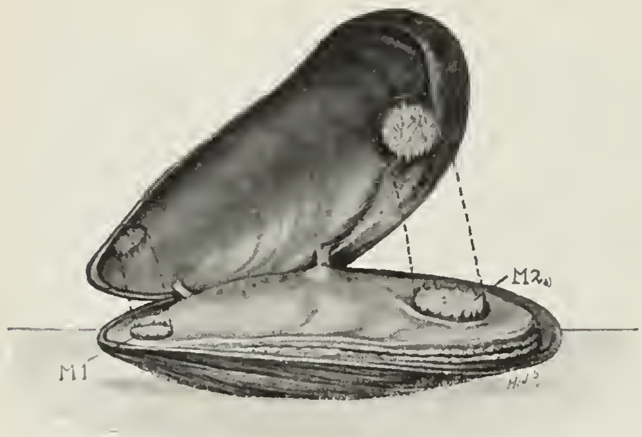
One who knows how can open the shell. We will tell you. Insert your fingers and pull stead-

THE TWO MUSCLES OF THE MUSSEL.
Pulling against the fingers which are trying to separate the shell.

ily, not trying to open it at once, but simply to keep it from closing. The mussel's muscles will

soon get tired, and then you can open out the shell without difficulty.

You have one muscle to extend your arm and one to bend it. You have two muscles to open

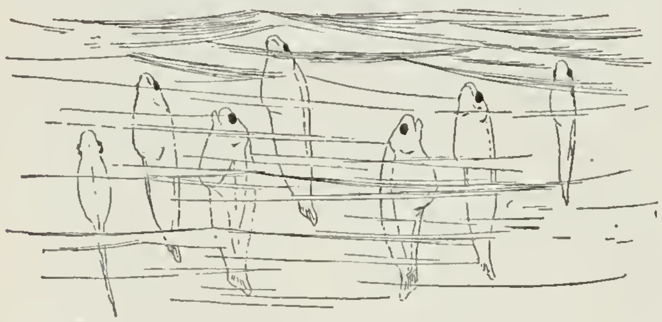


SHOWING THE MUSCLES (M^1 AND M^2) CUT ACROSS.
The shell now opens out easily.

your mouth and six to close it. The mussel, being inside of the shell, cannot open it by means of a muscle; but his two valves are joined by a great ligament so arranged that it will hold the shell open all the time. The shell is open unless the two big muscles are acting.

"AS FLAT AS A FLOUNDER"

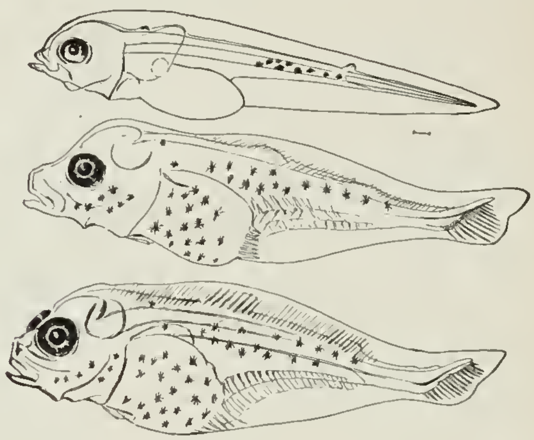
FLOUNDERS are among the commonest, best known, and most remarkable of salt-water fishes. While most abundant in northern waters, they



NEWLY HATCHED FLOUNDERS.
They are entirely transparent, except the eyes, and swim vertically, with the head toward the surface.

are found also in the temperate and tropical regions, and are so widely distributed that there is scarcely a seashore or bay anywhere in the world which has not one or more representatives of the flounder family. The largest and most important of the flounders is the halibut, which attains a weight of four hundred pounds. It is much sought by the fishermen of the United States, Canada, Great Britain, France, Norway, Japan, and other countries of the north temperate zone. The flounders are bottom-loving fishes, and pass most of their lives lying on one side, either on or partly buried in sand or mud, at depths ranging from a few feet to several thousand feet. As the food of flounders must always be sought above them, and as their enemies always come from above, these fishes would have no use for an eye on their under side, hence both eyes are on one side of the head. The under surface of the body, being out of sight, has no marked color, while the upper surface is richly pigmented, the shade and pattern of coloration corresponding with the nature of the bottom on which the fishes may rest.

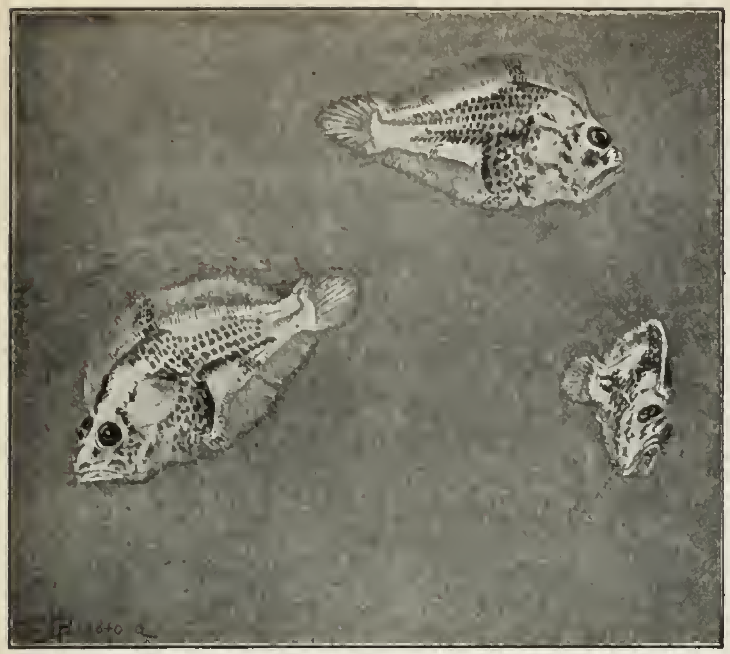
The expression "as flat as a flounder" has become proverbial, but it does not apply to very



THREE STAGES IN THE LIFE OF A YOUNG LEFT-SIDED FLOUNDER.
In the bottom figure the right eye is seen coming around the front of the head to take its place beside the left eye.

young flounders, which differ so much from the adult ones that they can hardly be recognized as belonging to the same family as their parents. Most boys and girls are familiar with full-grown flounders, but very few young people, and indeed few older people, know anything about the appearance of young flounders and the wonderful transformations they undergo. In spring and summer it is possible for young nature-students to secure specimens of newly hatched flounders by dragging a fine-mesh net on sunny days when the water is smooth. Such specimens may easily be kept alive in dishes of salt water, and examined from time to time with a low-power microscope.

The flounders begin life as do ordinary fishes. When they first emerge from the egg they swim vertically, with the head turned upward. Their bodies are symmetrical, and their eyes are on opposite sides of the head. Gradually the position of the body changes from vertical to horizontal, and the fish remain thus for some time, swimming like ordinary fishes; but while still very small there is foreshadowing of the bottom life they are destined for, and they enter upon a



THE YOUNG OF THE WINDOW-PANE FLOUNDER.

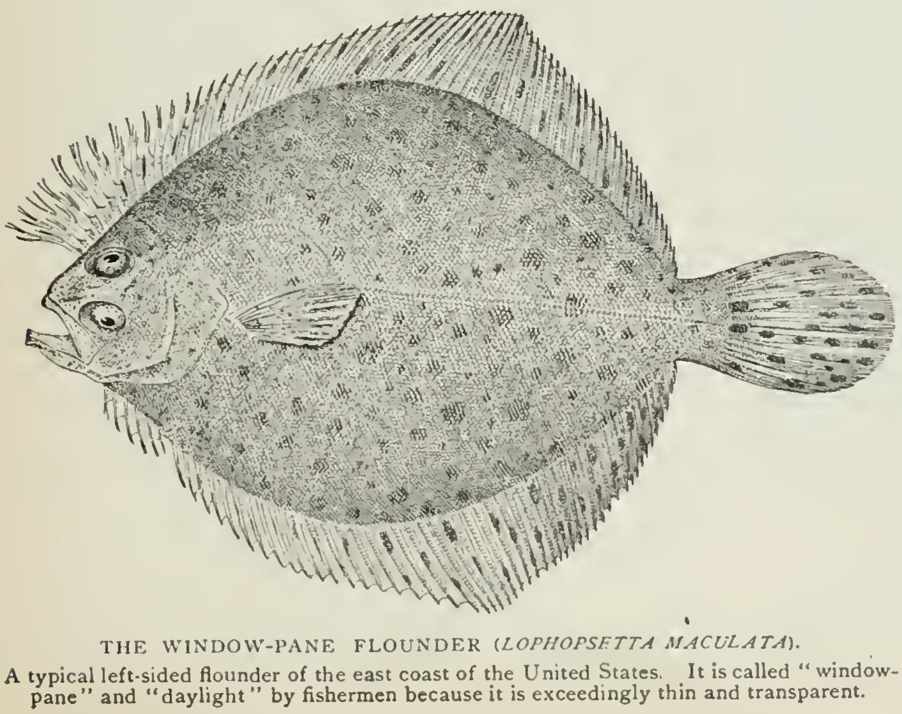
This is a left-sided species. In these figures the right eye has begun its passage across the forehead to the left side. The dark spot below the right eye in the upper figure is the left eye seen through the transparent head.

series of remarkable changes. The most striking of these changes is in the position of the eye. The eye of one side or the other slowly but steadily moves over to the opposite side of the head and takes a place beside the other eye. In some flounders the eye moves around the front of the head; in others it moves directly through the head. This shifting of the eye's position is accompanied by a change in the position of the body, which ceases to be upright and becomes more and more oblique. The side of the body from which the eye is moving gradually becomes inferior to the other, until by the time the change of the eye is complete the fish swims with its blind side underneath, and this position is ever after maintained. The flounder then ceases its free-swimming habit and sinks to the bottom.

Some species of flounders are right-sided and others are left-sided. In the right-sided forms, the left eye moves to the right side, and the left side becomes undermost. In the left-sided species the opposite conditions prevail. It rarely happens that right-sided species have left-sided individuals, and vice versa. In a few species both right-sided and left-sided fish occur in about equal numbers.

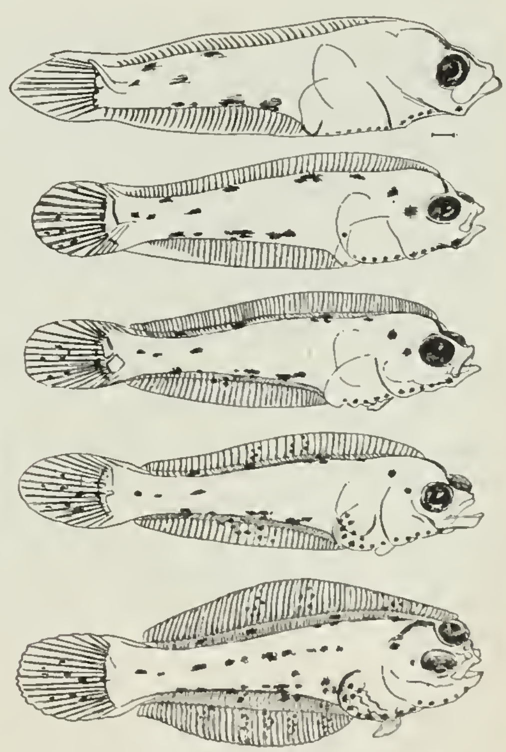
Soon after hatching, the flounder's color begins to appear in the form of small star-shaped masses of pigment on the body, head, and fins. These increase in number as the flounder grows, and finally run together and give the fish its peculiar pattern of coloration. The pigmentation of the under side begins to disappear soon after the eye changes its position, and when the bottom-living stage is reached no color remains on the blind side of the fish.

The flounder fishery is carried on chiefly during the winter and spring months, large quantities being taken. As a food-fish the winter flounder holds a very high rank; the flesh is white, firm, and of excellent flavor. Next to the halibut it is the most important flatfish of our Atlantic coast. This species has been more extensively propagated than any other member of the family. The United States Fish Commission obtains the



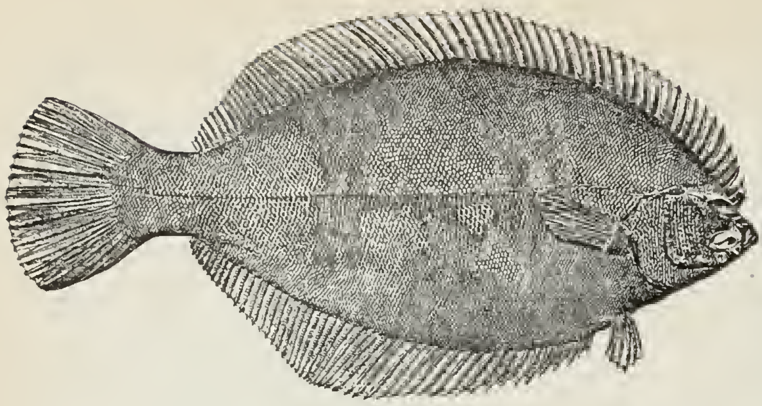
THE WINDOW-PANE FLOUNDER (*LOPHOPSETTA MACULATA*).

A typical left-sided flounder of the east coast of the United States. It is called "window-pane" and "daylight" by fishermen because it is exceedingly thin and transparent.



STAGES IN THE LIFE OF A YOUNG RIGHT-SIDED FLOUNDER.

Showing change in the position of the left eye.



THE WINTER FLOUNDER (*PSEUDOPLEURONECTES AMERICANUS*).
A typical right-sided flounder of the Atlantic coast of the United States, and an important food-fish in New England and New York.

eggs at Woods Hole, where its propagation fills in the time between the taking of the cod on the one hand and the lobster on the other.

"SLAP" AND "SNAP"

"Slap" was a frog. We called him Slap because when he jumped and landed on the hard floor, as he was in the habit of doing whenever he could get out of the pond, it sounded like a slap of mud on a stone.

His "slaps" were always unexpected in both time and place. Once Slap's slap was a crash. That was when he landed on the edge of a projecting sheet of glass over an aquarium. He went down; so did the glass. One difference was that Slap held together.

"Snap" was short for snapping-turtle. He had a way of making things short, especially a small stick that the young folks were fond of putting in his mouth, although his experiments along this line were not confined to sticks. One day he tackled a bullfrog and shortened him by a leg, and incidentally shortened his life.

You see that Snap was rather a dangerous fellow. So we cautioned the young folks who played by the pond-side and watched the antics of frogs, turtles, fish, and water-insects.

Slap was an explorer. He tried to find the north pole. At any rate, he climbed up the wire netting of a north window and jumped on a pruning-pole laid across some braces just under the roof. It took him as much as five minutes to find the pole. The pole turned, and the explorer returned to the floor in less than a second.

Snap was a stay-at-home. He was perfectly contented to lie for many hours in the mud and wait for a fish to swim within reach. To such a fish he extended a cordial invitation to come in and visit him. Whether or not the invitation was accepted in that form, I am not sure. I know that a fish was soon missing.

Snap was a great racer, although from his actions and appearance you never would have surmised it. One day, however, he showed what he could do in that way. He had been placed on a high table to be photographed. This table extended in front of a row of cage doors, and was attached to the wall just under them. One of these doors, through some one's neglect, had not been fastened, so "Pete," the white rabbit, came out—just to see what was going on, I suppose. He was disappointed in that—he saw what was going off. Just then my attention was called to something in another part of the room, and as I turned to attend to it the race began, both Pete and Snap making for the edge of the table. Snap came in, or rather down, ahead—at first on his head. He beat by several feet—two feet to the edge of the table, three feet down, and then four feet up—all four clawing in the air. Pete, peering cautiously over the edge, showed no disappointment because he had failed to arrive first. In fact, I have been a little in doubt as to what he did show, or indeed as to whether he ever fully appreciated the situation. I am inclined to believe that he did not. If he knew what he had escaped, he seemed unmoved by the thought.

Slap and Snap, though totally unlike in movements and disposition, were very friendly. My assistant said they were the best friends he ever saw. I asked him why he thought so, and he told me he supposed it was because they were always in the same "swim."

Slap and Snap were wise, too; they were philosophers in the art of living. At any rate, I gave them credit for that. Perhaps you would have said Slap mistook the turtle for an island when he jumped on his back and took a ride around the miniature pond. But I was charitable. I gave him the full benefit of the doubt, and said: "Slap is a genius. There he is, taking a free ride, apparently saying, 'This is the art of taking life easily. What 's the use of swimming when you can get some one else to do it for you?' "

And Snap, I fancied, said: "Might as well make the most of the burdens of life, and carry them as gracefully, humbly, and uncomplainingly as possible."

Poor Slap and Snap! Where are they now? Perhaps in the mud of the pond to which we carried them in late autumn; for you must know that this pond to which I have been referring as their summer home was a six-foot tank under the trap-doors of our nature-playhouse.

And down there in the mud, if Slap and Snap ever dream, I hope they are dreaming of the young folks to whom they gave many a laugh by their interesting antics last summer.

WONDERS OF INSECT LIFE

JEWELS ON SPIDER-WEBS

On dewy mornings a little careful observation will reveal on various small objects many beautiful forms of dew that are commonly overlooked. Nature seems often to put her most

A SPIDER-WEB WITHOUT DEW.

exquisite work in her smallest things. This is especially true of dew formations. To the observant eye the large drops of water in a gentle rain are seen to cling to many objects, as, for example, twigs, wires, stretched cords, and clothes-lines. Much more dainty, yet of similar form, are the dewdrops on the finest parts of plants and leaves. Perhaps the smallest object on which these tiny, pearl-like formations may be observed is a thread of a spider-web. Here the drops are so small that they do not elongate, but keep a beautiful spherical form.

The web is so fragile, however, that it is difficult to photograph these drops. Mr. Wilson A. Bentley, who took the photographs here shown, sets up three panes of glass around the web and places another pane on top. This makes a temporary gallery in which there are no currents of air to shake the delicate web. To secure a black background he uses a large pail painted black on the inside, and placed behind the "box" of glass. A box or pail thus blackened is better than a sheet of black cardboard or cloth, because the light sometimes strikes a black flat surface at such an angle that it photographs nearly white.

To secure a section of the dew-laden web, he bends a wire into a loop shaped like a tennis-racket, leaving one end to project as a handle, and smears the loop with Canada balsam or with some other sticky substance.

Find a web so suspended that you can place the wire loop beneath it. Then press gently upward until you detach and secure the whole or a part of it on the wire. Thrust the stem of the loop to a sufficient depth into the ground within the glass gallery, and arrange it properly as to height and position.

Center and focus the object by moving the camera about on the ground or on a board laid

A SECTION OF WEB WITH DEWDROPS.

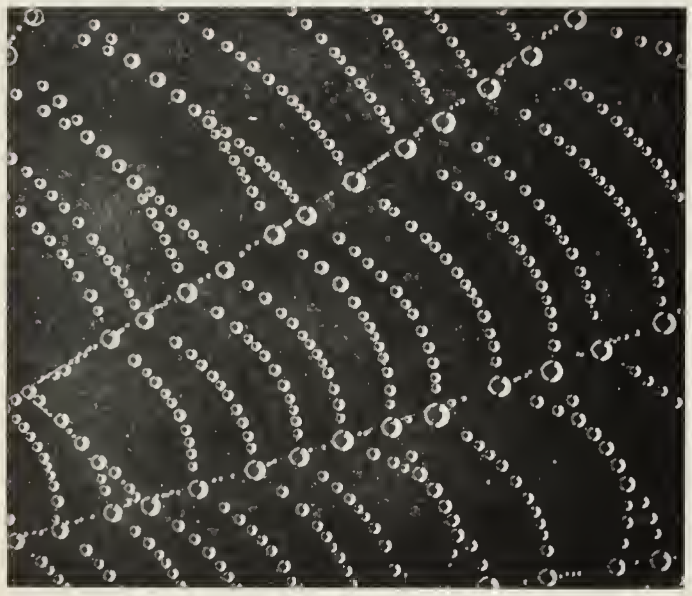
on the ground. Place a cap on the lens. Spread the focusing-cloth from the camera to the edge of the glass inclosure. Now lift the cover from the glass inclosure, remove the cap, place the

glass cover on again, and expose for from ten to fifty seconds or more, according to circumstances. It is best to use the lens well stopped down.

Many dew-laden objects may be photographed in their natural position, without removal to the

AN ARRANGEMENT OF DEWDROPS AND WEB SUGGESTING JEWELRY.

glass inclosure, provided the air is very still and the objects are so situated as to permit the placing of the blackened pail or other suitable background behind them. But when this is impossible, or when the breezes blow, they may be clipped off and placed within a wooden vise, or



A NEARER VIEW FOR BETTER DETAIL.

other firm holder, within the glass inclosure, and there photographed.

Dew photography should be a delightful pursuit the world over, on account of the great number of different forms of plants and other objects that each country affords, every one with its own charming way of collecting drops.

A WONDERFUL MOVING VINE

Near the bank of the Guadalupe River, I saw something green upon the ground, and, hurrying forward, found a lovely vine with leaves smaller

THE WONDERFUL MOVING "VINE."

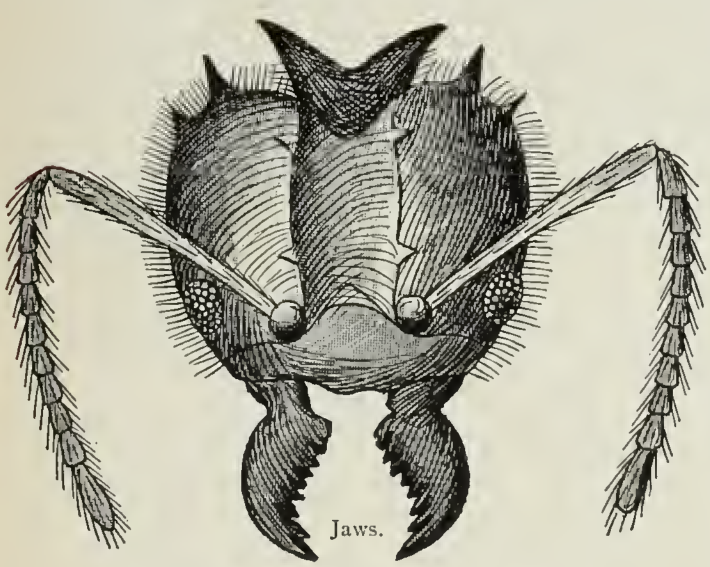
than those of the smilax, of a pale, tender green. The vine had its root about five feet from the trunk of a towering cottonwood-tree, and spread out on the ground four or five inches wide, becoming a little narrower as it approached the tree. I could see no stems nor tendrils, so thick was the growth; and as I drew close to the tree I saw that the vine branched just above the ground and went climbing up the great trunk and the branches. It grew more and more slen-

der, until, far up, I could distinguish only a threadlike line of green.

As I stood intently watching the delicate, graceful vine, I became aware that it was per-

ANTS CUTTING OFF LEAVES OF THE COTTONWOOD.

vaded by a curious, tremulous motion. Then I saw that the individual leaves were not stationary. Picking up a twig from the ground, I touched one of the leaves and found to my amazement that there was a brown ant under it about as long as my little finger-nail. Each leaf



THE HEAD OF A LEAF-CUTTING ANT.
To show the sharp, saw-like jaws.

was held in the mandibles of an ant in such a way as to conceal the body of the insect, and the ants were coming down the tree. The discovery came upon me with a shock. I had stumbled on a nest of umbrella-ants. Books had told me that such ants were found in the tropics, where they carried bits of leaves over their heads as if to protect themselves from the sun; but here, on the banks of a Texas river, I had found a colony of them, shading themselves where there was no sun, and completely hidden by their covering of green.

Charmed at the sight, I turned back to call my companions, who were fishing in the river. Within a few yards, I met my husband coming to look for me. He was even more excited over the phenomenon than I was, and shouted for the others to come quickly. On investigation we found that the spot where the vine seemed to have its root was really the opening of the ant-nest. The tiny creatures had by some instinct learned that the topmost branches of the cottonwood had put out their first small leaves. They had climbed the immense distance and had cut off and brought down their leaves—to feed their young ones, we supposed. The ants which issued empty-jawed from the nest made a long circuit to the farther side of the tree and climbed up where they would not interfere with the leaf-bearing thousands coming down.

HOW THE HORSE-FLY BITES

It is not unusual, while riding along a wooded country road in the summer, to observe the annoyance that the horse is forced to bear by reason of the swarms of small flies that attack his head and neck, and it is nearly as common to witness the assaults of another and larger fly, which, although it does not occur so abundantly, is numerous enough to destroy the pleasure of the ride, and to keep the horse in a constant state of restlessness and of nervous excitement. These larger flies have the habit of making a sudden dash under the horse's head, or of striking him in some other part not reached by the sweep of his tail, the attacks, if at all frequent, making the animal wild with pain.

Being curious to learn how these insects manage to draw the enormous amount of blood that follows their bites, I captured several of the larger forms, and, on reaching my home, dissected the mouth-parts and laid the organs on a slide, so that they might be examined by the microscope. The photograph herewith presented gives as correct a view of these piercing instruments as may be had through a good objective, for the picture not only exhibits all the mouth-parts, but also gives a distinct view of the two compound eyes.

It might be supposed that to obtain the blood these insects employ as simple a process as that used by the surgeon, but, instead of his single lancet, these flies, as well as other insects that live on the blood of the higher animals, are provided with an outfit of instruments consisting of no fewer than five distinct pieces, all of which are carried under the chin, and, when not in use, are carefully inclosed within an elastic sheath.

The five parts referred to, consist, as shown in the figures, of the blood-sucking tube, marked A, the central piece; two knives, B, B; and the two

THE MAGNIFIED VIEW OF THE TONGUE OF A HORSE-FLY.

hooked pieces, C, C. These are the only organs directly employed to draw the blood, but, in addition to them, there are a pair of feelers, or palpi (E, E), used to locate the best point of attack.

All these, except the palpi, are closed when not in use, and are included within the proboscis, D, which has a slot along the lower side, through which they are protruded. This proboscis, by the way, is similar to that of many other flies, and when blood is not available, may be used to take other nutritious liquids.

It will be observed that, in the process of "biting" or of drawing blood, the central piece of the sucking tube is too blunt to be forced through or even into the tough skin until a cut is made to receive it; so the two knives, B, B, with extremely sharp points and keen edges, are ready to perform this office. But when the cut has been made a little leverage is required to hold the pumping tube in place, so the other two pieces, C, C, which under a high magnifying power are seen to be lined with sharp teeth pointing backward, are inserted, and hold the parts firmly, while the central tube is forced into the cut.

It may be well to remark that only the females among the horse-flies, mosquitos, and similar insects, have mouth-parts adapted to draw blood. The males have the usual proboscis, but not the blood-taking tools. Unlike the mosquitos, none of the horse-flies of this country insert poison into the wound, although some occasionally bite human beings.

THE WONDERFUL SILKWORM

If a boy had money enough, he would like to buy his mother, or his sister, a silk dress for her birthday. Much pleased she would be to have it. But if he said to her: "Here is a caterpillar gown for you," she would be horrified and call him a dreadful boy. Of course, a silk dress is not really a caterpillar dress, for that would mean that the dress was made of caterpillars. But though this is not the case, the material, if it be pure silk, comes entirely from the caterpillar, only we call the caterpillar in question a silkworm. That is merely a way we have. We call the silk-yielding caterpillar a silkworm, and we call the light-giving beetle a glowworm. Many things go by wrong names in common speech, and the result is that, when we study natural history, we are surprised to discover the true nature of the things we have so long misnamed.

The material of the silk dresses that our mothers and sisters are fortunate enough to have, is made by a very ordinary-looking, big, fat caterpillar, and boys who keep caterpillars of this sort may, if they like, become silk merchants on a small scale. The silkworm is as much dependent upon man as is the canary in its cage. If all the tame silkworms in captivity were turned loose, the bulk of them would die. They depend upon us for their living, and we depend upon them for our silk. We can make lovely scents and sweets from coal-tar; we can make all sorts of things in the laboratory of the chemist, but not all the wisdom of man can make a piece of silk. How came man, then, to have these wonderful insects to work for him, and how came they to depend upon man for their safety? It is a wonderful story, and takes us back thousands of years.

It was those wonderful people, the Chinese, who first discovered the use of silk. They learned that it could be woven into material for dresses, and they learned how to get it from the silkworm. They found that the caterpillar or the silkworm could be kept alive in captivity; that it would thrive as a prisoner, if kept clean and fed on mulberry-leaves, quite as well as if it were at liberty. So they kept the caterpillars, and when these turned into moths, they kept the eggs that they laid, and when the caterpillars spun cocoons of silk in which to live, they took a cer-

tain number of the cocoons and unwound the silk of which they were composed, and made the silk into dresses. What the Chinese were doing with caterpillars nearly five thousand years ago, the people in many countries are doing to-day, and all for the same purpose, that men and women may have silk to wear or to use for the thousand and one purposes for which this beautiful fabric is so much sought. Let us see what this wonderful process of nature is that gives the world its silk.

FORTY THOUSAND EGGS THAT WEIGH ONLY AN OUNCE

We will suppose that we are setting up for ourselves as keepers of silkworms. The eggs—the only things that we need—can be bought, and we can set to work to gather silk this very summer. It is better fun even than keeping ants, for here we can see all that happens in the process. With how many eggs shall we start? A pound? No, nor an ounce. They are so light that there are about 40,000 eggs of the silk-moth to the ounce, or about 100 to a grain. Of course, we must have a proper place—a greenhouse is a good place—in which to keep the eggs, where we can be sure that the temperature will not fall below 62 degrees, nor rise higher than about 80 degrees. The heat may be increased as the time for hatching draws near, but it must never be more than 80 degrees. As a matter of fact, the lower the temperature, so long as it is not lower than 62 degrees, the stronger and better the caterpillars will be.

Thousands of poor people, however, have bred silkworms who could never afford a greenhouse. How did they manage? Many of them have put the eggs carefully in a bag and carried the bag tied round their necks so that the warmth of their bodies might hatch the eggs.

WHEN AND HOW TO HATCH THE SILKWORM EGGS

With ordinary care there is no difficulty about hatching the eggs, but we must be ready for the day when they do hatch. First of all, we must be sure to have a supply of leaves of the mulberry-tree ready. It is of no use our hatching the eggs if this tree is not in leaf. The caterpillars would eat lettuce, but they would not be nearly so fine, nor would their silk be worth much, after a diet of this sort. The next thing is to see that we have ready a very thin card, or piece of paper, pierced by little holes, which may rest on a ledge in the box, over the eggs. The little caterpillars, as soon as they are hatched, will see the light through these holes, and will crawl toward the light through them. In doing so, they will scrape off the shells clinging to them, and so escape all risk of being killed by being unable to free themselves from the shells. The caterpillar of other moths, as soon as he is born, makes a meal of his shell, but the silkworm needs this little help.

Now comes the first enjoyment of silkworm rearing. We can have a great many in a single big cardboard box, but we must be careful that this does not become crowded, or there will be trouble when the time for cocoon-spinning comes. Better have three or four big boxes, like those in which the tailor sends home clothes, than that the silkworms should suffer for lack of sufficient space. It is a great convenience that we may safely leave the box open. We could not do this with any other caterpillars, for they would escape.

THE LITTLE SILKWORMS THAT WILL EAT A FOREST OF LEAVES

Not so the silkworm. It is as happy as can be in a box without a lid, provided it has plenty of food, and that the box is perfectly clean. Keep down the heat to as near 62 degrees as possible, and the silkworms will grow big and strong. They eat a surprising quantity of mulberry-leaves.

We are not going to have a whole ounce of eggs, with 40,000 silkworms hatching out; but, in order that we may get an idea of the appetites of these insects, we will suppose for a moment that we have this number. During the eight weeks that they live in the caterpillar stage, the 40,000 silkworms will require 1362 pounds of mulberry-leaves. Of this quantity, about 590 pounds will be wasted, for we take out all dry and stale leaves. But there remain 772 pounds to account for. That amount the caterpillars actually eat. We have to exercise care in the feeding; to distribute the food evenly, so that the caterpillars shall not have to struggle and fight for their meals. A good way is to cut up the leaves small, as this makes the distributing easier. The pace at which the caterpillars grow is surprising. Like other caterpillars, they have to molt—that is, to cast their skin. The skin in which they are born does not last all their lives.

HOW THE LITTLE SILKWORM CHANGES ITS SKIN AND GROWS BIG

When they are about six days old they cease to feed. The skin splits down the back and the

caterpillar crawls wearily forth, bearing his new skin about him. His appetite returns, and he eats more heartily than ever. He grows rapidly when the new skin is still soft. But, after a few more days, another new skin is required, and after that a third, and finally the fourth.

Each molting-time is a period of serious trial for the silkworms, and many die during its progress. Once the last molt is over, however, the caterpillar eats away as if it knew that its days for feeding were numbered. By this time it has become one of the biggest of all our caterpillars. Whereas it was at birth only a speck, weighing the hundredth part of a grain, it has now increased its weight to about 95 grains, and its length to three inches or thereabouts, which is a very rapid growth for two months. Now comes the most important time of the caterpillar's life. It has to become a chrysalis, and it is in order that it may safely pass through the chrysalis stage that it spins the famous silk.

All the time that the silkworm has been growing up, it has been forming and filling two large vessels, or sacs, that run along the sides of its body. In these two sacs is stored a sticky fluid. If we saw it in its natural state—that is to say, the state in which it is while still in the body of the caterpillar—we should not have the least idea as to what it was.

THE STICKY STREAM THAT BECOMES A STRAND OF GLOSSY SILK

That sticky stuff in the body of the caterpillar is to become the marvelous silk which makes the insect so valuable. When it is about to spin, as we call it, the caterpillar ceases to eat anything. As we watch, we see two tiny streams issue from its lower lip. That is the silk issuing from the spinnerets, or seripositors. It is as well that we should know the names, so that we may not have to puzzle when we meet them elsewhere. We must remember, too, the scientific name of the silkworm. It is the *Bombyx mori*. Well, then, the *Bombyx mori* begins to spin its cocoon by producing two tiny streams of silk from its spinnerets, or seripositors. The sticky fluid, if we force it from the body of the silkworm, becomes hard at once; but, manipulated by the silkworm, it is drawn out into beautifully fine strands of silk. The two strands are joined together by the silkworm to form one thread, and it is only by the aid of the microscope that we are able to discover that there are two in the thread. With this material, the silkworm weaves itself the loveliest house of silk.

The work may take two, three, four, or even five days. Little by little, the silkworm builds up this castle of silk, weaving it so perfectly that at last the worm is entirely shut in and quite invisible. All the time that it is thus building, the silkworm works its head round and round in a regular order, never wearying. And all the time the silk never fails.

A DAINTY GLOBE OF SILK THAT LOOKS LIKE A FAIRY EGG

The silkworm, at the beginning of the task, weighs over 90 grains. When the labor is ended, the silkworm, with its cocoon, weighs only about 50 grains. And there it is in a lovely globe of tightly woven silk, looking like some fairy pigeon's egg. The cocoon may be either white or pale yellow. Having watched the spinning, we realize why we ought to be careful that the silkworms have plenty of space. If they are at all cramped, two will spin together only one cocoon, and this will be useless.

If we leave the cocoons alone, there will come forth, in about fifteen days or three weeks, a pretty moth from each. The average length of the moths is about an inch, but the males are slightly smaller than the females. They can be kept on a cloth. They eat very little, and sometimes even nothing at all. The females lay 500 or more eggs, and then die, and the males do not live long after them. Their whole lives as moths last but a few days. In that time, they never try to fly away. The females cannot fly at all; the males have just enough power in their wings to steady themselves in descending, but they cannot possibly fly upward.

In this, we see the result of thousands of years of care and attention on the part of man. The *Bombyx mori* has always been the one species common everywhere as man's silk producer. Certainly, there are others in captivity in China and Japan, but they are not of much importance. In Europe people have never been able to do much with them. There are wild silkworms, too, but their silk is of little use to man, so there has been no attempt to cultivate them. Those that have been allowed to remain wild can fly about as well as any other moths. Only those that have been cared for by man have given up the power to fly. If they could, they would fly away, and we should never know where to look for their silk.

So far, we have traced the silkworm from the egg to the caterpillar, and from the caterpillar to the moth. What of the silk, of which we have talked so much? Here we come face to face

with a little tragedy. Every silk dress means the death of thousands of silkworms.

WHY THE SILKWORM MUST DIE IN ORDER TO GIVE US SILK

THAT sounds dreadful, but it is not so in reality. The life of the silkworm, as a silkworm, is ended when the insect has reached the chrysalis stage. It is then in a state of torpor, and can have no sense of feeling, unless time and care are given to rousing its sleeping energies to a sort of wakefulness. That is not done. When the cocoons are all ready, we have to decide how many moths we want to renew our supplies of eggs. We take away those for the nursery. The others we want for silk.

These we plunge into scalding water. Manufacturers steam them, or submit them to a high dry heat. This kills the chrysalis. The reason why this has to be done is, that if life remained in the chrysalis, the latter would turn into a moth, and would then form an opening at one end of the cocoon out of which to creep, so spoiling the cocoon.

The next step is to wind the silk on to reels. To do this, the cocoon has first to be softened in warm water of from 75 to 85 degrees. The water dissolves the gum that binds the silk threads together. A neat-handed girl then twirls the cocoons about with a light brush, that catches the loose ends and causes them gradually to unwind. All that we have to do is to undo the work that the caterpillar did. But the silk is far too fine to be wound in this state. In the thinnest part, the silk is so fine that 1000 strands of it, laid side by side, would cover only an inch, while, in the thickest part, from 600 to 700 strands would be required to make up an inch in thickness.

SOMETHING THAT THE WISEST MAN CAN DO NO BETTER THAN A BOY

So, when the ends of the silk are discovered, the operator joins four or five together, passes them through a fine eye of glass, or polished metal, in a winding machine, and, letting the cocoons remain in the water, winds away until all the silk that can be used is wound out from each cocoon. The silk is wound on to a big wheel, and care has to be taken to see that the strands do not stick together. In Eastern lands and in some parts of Europe they use machinery so simple that a boy could make it; but in big factories they have much improved on this. Still, the principle is everywhere the same, and at this stage the wisest man in the world could do no better than any boy or girl who has had a little experience with the winding.

Once the silk is freed from the cocoon and wound on wheels, or whatever they may be, it is ready for the manufacturer. Many processes follow. The silk has to be freed from all the gum remaining on it, for at present it has no luster such as we expect silk to show. It has to be cleaned by boiling, to be scoured, and purified by acids. That is one way. Another is to let the silk begin its own purification by a process of fermentation, which means the shutting up of the uncleaned silk in tanks containing soapy water, in which the silk may lie for weeks. Then follow all sorts of washings, and finally drying.

HOW TANGLED SILK IS COMBED STRAIGHT BY A MACHINE

THEN we have the silk clean, but terribly entangled. Wonderful machinery combs out the tangle, and makes all the strands of silk straight, and smooth, and even. Finally, the silk is ready to be made up into dress-materials, or into whatever may be required, just as if it were wool or cotton. A garment of pure silk lasts a very long time, for there are few materials that wear better. Unfortunately, some manufacturers have discovered a way of adulterating it while the cleaning process is being carried out. They add salts of metals that are absorbed by the silk. This adds weight to the silk, and makes it appear a fine heavy fabric. But silk made by such dishonest methods soon rots. It is this adulteration that makes silk "cut" so readily, and makes a silk garment, or silk umbrella, become full of slits even when it is not much used.

HOW SOME STOLEN EGGS GAVE EUROPE SILK FOR 1300 YEARS

IT is very wonderful to think that all the millions of silkworms that for 1300 years produced the silk upon which the whole of Europe mainly depended came from the batch of eggs stolen by two monks from China. So, however, it was. The art of making silk began, as we have seen, in China. The Chinese guarded their secret as closely as they could. They thought it good that their people should know how to make silk, but they did not want people in other countries to know how to do it. If other people wanted silk, they must buy it of the Chinese, not make it for themselves. They sold a good deal to Rome, for Rome in all her glory could not produce silk for

herself. This state of things lasted until 550 years after the birth of Christ. Then the wise Emperor Justinian, who ruled in Constantinople, saw how important the silk trade was, and determined that he would create a trade in silk for the Roman Empire.

Two Persian monks, who had long lived in China, told him that they had seen the whole process of rearing the silkworms, and the manner of treating the silk. So he sent them secretly to China to get him some eggs of the silk moth. They walked all the way from Constantinople to China, and they walked back again, but they brought with them some of the precious eggs.

THE SILKWORM'S EGGS THAT CAME TO EUROPE IN A BAMBOO STICK

It would have cost them their lives, had the purpose of their visit been known. They knew this, and were very careful. They got a supply of eggs of the silk-moth, hid them in a hollow bamboo, and then carried them to Constantinople and presented them to the Roman Emperor, who ruled in what is now the capital of Turkey. The Emperor was delighted. The eggs were hatched, and there appeared, for the first time in history, a number of silkworms in Europe. From each female moth he would get 500 or more silkworms, and from these in turn there would be another great increase. The monks had brought him, in the little bamboo nest of eggs, the richest goldmine that they could have given him.

The Emperor caused a silk factory to be set up in his royal palace. Only those whom he appointed—trusty women, who worked under the direction of the monks—were allowed to manufacture silk. But, in course of time, the eggs of the silk-moths were carried to other countries. In Italy and France many towns became famous for their silk manufactures. Frenchmen, persecuted on account of their religion, fled to England, and took with them the secret of manufacturing silk. That secret gave vast riches to England, though she had to buy raw silk from France and Italy.

VAST SUMS LOST THROUGH A DISEASE AMONG THE SILKWORMS

English kings tried by every means in their power to get the cultivation of the silkworm taken up in their colonies, but it was never successful. Still, the manufacture of silk into articles of use became very important to the home country. It was still more important to Europe. We may gain some idea of its importance from what happened when a terrible disease broke out among the silkworms of Italy and France during the second half of the nineteenth century. In spite of the disease, there were always some healthy caterpillars producing silk, and the trade never came to a standstill; but the damage done to that part of the trade which failed robbed France and Italy, in only thirteen years, of $600,000,000.

It was only then, after all those centuries, that Europe had to send again to the East for more eggs of the silk-moth. During 1300 years Europe had been stocked with its millions and billions of silkworms from the descendants of those silkworms which came from the eggs carried away in a little bamboo by the two monks at the command of Emperor Justinian.

THE "LOBSTER" ON THE HOUSE-FLY

"The other day I saw the queerest thing that I have ever seen in all my life," said a lady. "I was swinging leisurely in my hammock on the veranda when a fly with something dangling from its leg alighted on the railing. I stopped swinging and examined it. The fly was the ordinary house kind, but on its leg was a little, red, lobster-like creature."

It was a chelifer, and this special one was taking a ride at the expense of the fly. Although the little crab-like creature can walk backward as rapidly as forward, it not rarely wants to move faster or to transfer itself to another locality, when, by seizing the leg of an unsuspecting fly, it accomplishes its purpose.

Chelifers are said to be cousins to the spiders, scorpions, and daddy-long-legs on account of their structure, which is of interest to the naturalist. They are found under fallen leaves, under loose bark on dead trees, and one species occurs in houses almost everywhere throughout the world. They feed on tiny insects or mites which they capture by means of their large claws. The mother chelifer lays a number of small round eggs which she carries in a cluster attached to her lower surface until they hatch, when the young ones take care of themselves. Those living under bark make a tiny nest of bits of the wood, there shedding their skin, and passing the winter. They are perfectly harmless. They have no poison-glands and can neither bite nor sting.

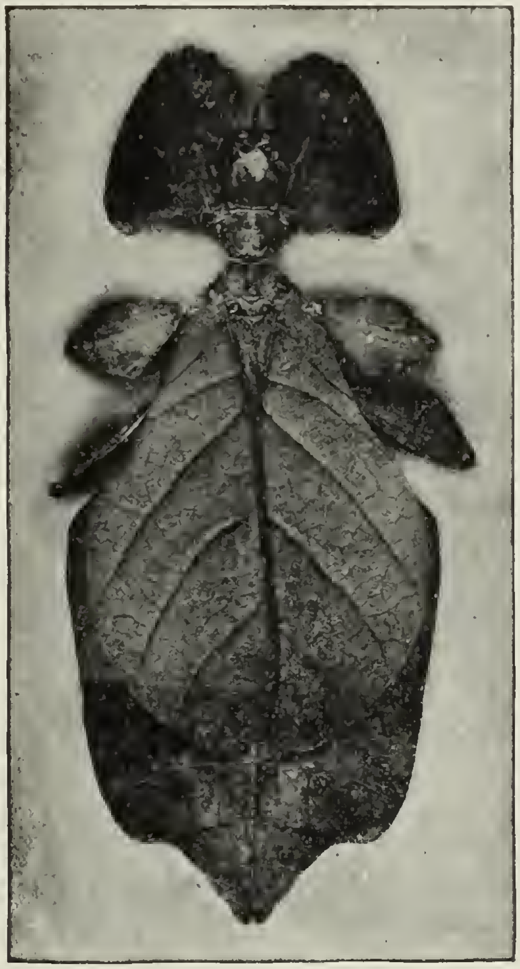
THE FAMOUS LEAF-INSECT

We all know how the wings of the katydids, and of some other insects, closely resemble the green

leaves among which the creatures are found. The walking-stick insect is like the green twigs on which it is found, and the roadside grasshopper cannot easily be told from the sand on which it alights.

Even a very little careful observation will find many such deceptions, which are of great interest to the young folks as well as to the learned grown-up people.

One of the most interesting examples of protective resemblance is the green-leaf insect (*Phyllium*), which is found in South America.



THE LEAF-INSECT.

Not only the wings, but body, legs, head, and even antennæ are leaf-like, of a bright green color. The markings of the wings appear to be leaf veins, and there are often small yellowish places in near imitation of decaying, stained, or fungus-covered spots on the leaves.

The accompanying illustration was photographed directly from one of these very wonderful insects.

Protective resemblance is not limited to such striking examples as this leaf-insect. Very many forms, large and small, of animal life are somewhat or wholly hidden by resembling the surroundings.

AN "OUT-OF-DATE" BUTTERFLY

If any of our young readers who like to go butterfly-chasing had been in South America in the year 1898, or some of our older friends had been there in 1889 and found the *Callicore clymena,* they might have thought that the butterfly not only came from the chrysalis that year, but had taken to wearing a date, so that all naturalists might be sure from at least one wing that there was no mistake about the year in which it appears.

THE CALLICORE CLYMENA BUTTERFLY.

The dark lines form very distinctly the figures 89 on one wing and 98 on the other. Of course this is merely an interesting coincidence, without purpose or benefit as to dating; but some one, finding this *Callicore* in 1900, was led to exclaim, "Why, that butterfly is out of date!" But nobody could say whether it belonged to past or future '89's or '98's.

THE FIRECRACKER BUTTERFLY

If you have ever chased a butterfly, you know how well it is fitted to escape from its enemies by swift flight and skill in dodging. Just as you dash the net in full confidence of capture, you are surprised to see the insect far away in the field, or high in air, perhaps among the topmost branches of a tree, if you are butterfly-hunting in or at the edge of a forest.

A butterfly in South America, known to the naturalists as the *Ageronia,* makes a loud snapping noise when flying, so that we may well call it the firecracker butterfly. It pop-pops and snap-snaps in quite a startling manner as it flies here and there, and thus is not only able to get away from its enemies, but to frighten them away. Apparently the butterfly is noisy the greater part of the time, not so much for protection as for enjoyment in the popping, like a boy on Fourth of July with firecrackers.

You see, the closer and more extensively we study even the smaller members of the animal

kingdom, the more we find that "one touch of nature makes the whole world kin," and that the birds, butterflies, insects, etc., seem in some respects very much like human beings.

THE AGERONIA BUTTERFLY, THAT MAKES A SNAPPING NOISE LIKE A SMALL FIRECRACKER.

Discovering all these queer habits and traits of our little friends in the fields and forests makes the study of nature so intensely interesting.

SOME INSECT FOES

Few of us imagine how important a part in the history of the world little insects play. Next to the poisonous snakes, they are really more to be dreaded than any other form of animal life. There is nothing else living that does so much damage to property. A lion or a tiger is more terrible to face than a mosquito, but the innocent-looking mosquito may cause death as surely as the fearful man-eater. Animals are big and comparatively few; insects are little, but their numbers are great, they are more than men can count, and the insects are not discovered until their damage is done.

How a plague of insects begins, it is not always easy to say. But we know how one began, and we may get an idea from that as to what happens in other parts. Until after the middle of the last century, the gypsy-moth was unknown in Massachusetts. Then an unfortunate thing happened. A French scientist was performing experiments in his laboratory with the window open, when a gust of wind carried out into the garden a few eggs of the gypsy-moth that had been sent to him at his Massachusetts home.

Those few eggs hatched, and the caterpillars became moths and laid many more eggs. So terribly did they increase that within a few years the gypsy-moths had spread over an area of 220 miles. Men tried in vain to fight against the plague. The caterpillars swarmed in the trees and ate them bare, as if a fire had swept over the land. Over 40,000,000 trees were raided again and again in this way. The State spent as much as $90,000 a year for many years in succession, but still the plague continues, and still Massachusetts is robbed of much wealth by this pest.

The Colorado beetle is another dreaded enemy of the farmer. It is a rather handsome little beetle with its orange-colored, black-spotted coat, but it completely ruins the potato-crop wherever it gets a hold. Until recent times it existed only on wild crops, but then it got among the cultivated potatoes of Colorado. The mother beetle lays hundreds of eggs on the leaves of the potato-plant. The young ones hatch very quickly and lay eggs in turn, and then the young ones from these lay eggs—all this in one summer. During the winter they go to sleep in the ground, but they wake up in the spring, and attack the plants so that in some parts the potato-crops are completely destroyed. Any person found with living specimens in his possession is heavily fined.

Then there is the cuckoo-spit, or froth-fly, or froghopper, or frog-spit—it has all these names in different places. It is the insect that lives on stems of grass and many other growths. There are many varieties of it. It sucks the juice of the plant or growth upon which it lives, and forms a dwelling of froth, supposed by many to be little bubbles blown by the cuckoo. If we remove the froth we find a surprising little animal inside, a yellowish-green insect with long hind legs, with which it can hop like a frog. A little girl discovered one of these insects by making the sun shine through a magnifying-glass upon the froth. Out pounced the froth-fly, looking as surprised and angry as an insect can look.

Now, the froghopper serves to introduce us to one of his most dangerous relatives, the cicada, which, though known in Europe, is most deadly in America. Here we call it the seventeen-year locust. This title we give it because it appears as a pest once every seventeen years. What happens is this: The male flies of the perfect cicada die soon after their wedding day; but the female fly lays about 500 eggs in the twigs of the tree upon which it settles, and then dies. But before it dies it inflicts terrible damage upon the tree. The eggs lie in the warmth and hatch, and the grubs, as soon as they are born, fall to the ground, and make their way into the soil. There they live for seventeen years, sucking the sap

from the roots of plants, and doing great damage.

MILLIONS OF DOLLARS LOST THROUGH THE WORK OF A FLY

At the end of their seventeen years underground they appear as flies, and then attack the foliage of the tree, completely ruining the fruit-crop. Of course, some flies of this family appear every year, but it is only once every seventeen years that the multitudes come forth to work havoc. In 1874 the attack of these flies caused damage in four States amounting to $100,000,000, and double that sum through losses in trade dependent upon the crops which these insects had spoiled.

There is another cicada known as the thirteen-year locust, so called because it appears in swarms every thirteenth year. The cicada is a curiosity because of its loud and musical chirping. Some people, when there is not a plague of cicadas, keep the insects in cages for the sake of their chirping, which, when the air is still, can be heard for a great distance.

Whenever we think of damage done by insects, however, our thoughts always turn to the locust. That was the first destructive insect any of us read about, for its terrible ravages are described in the Bible. The locust appears in just as great swarms to-day, and is every bit as much to be feared as it used to be in the old days.

ARMIES OF LOCUSTS THAT SOUND LIKE A RUSHING RIVER

There are many species of locust, and its family includes grasshoppers. Some locusts are only a quarter of an inch long; others are five inches in length. The female has a strong boring weapon, and with it she drills a hole in the ground, and there lays her eggs. When the young ones are hatched and grow strong they have hearty appetites. At first they have no wings. So they march in countless armies, in search of food.

They go straight forward, nothing turning them aside. Every green blade disappears as they go. If they are not stopped, they feed and feed, and presently their wings appear, and then they rise into the air and continue their progress by flying. Then it is that travelers see them in vast hordes. The swarms blot out the light of the sun. They fill the heavens as with a black cloud, and the noise made by the wings and the movements of their hungry jaws is compared to the rushing sound of a broad river. They alight from time to time; and suddenly, where a few minutes before appeared a field of corn or a grove of trees, nothing remains but a mass of stubble, or a forest of bare branches.

On and on they go, traveling to lands beyond the sea. They have been met in a cloud 500 feet high, 1200 miles from land. Wherever they have passed over land they have left ruin and desolation.

A BANK OF LOCUSTS FIFTY MILES LONG ON THE SEASHORE

Sometimes a great wind will blow the locusts into the sea. This happened toward the close of the eighteenth century, in South Africa, where 2000 square miles of land had been covered by them. A great wind blew them into the sea, and so many were drowned that when their bodies were cast up by the waves they formed a bank four feet high and fifty miles in length. Nothing can save the farmer over whose fields or orchards a swarm of locusts flies. The only hope seems to be to grapple with them before they get their wings—when they are marching on foot. Until 1881 they used to scourge the island of Cyprus. Then two clever men undertook to solve the problem, and mastered the locusts. It was a wonderful thing that they did—wonderful because, though it was successful, it was so simple. It was solely the result of watching the ways of the locusts.

MILLIONS OF LOCUSTS CAUGHT IN ONE YEAR ON ONE ISLAND

The young locusts always march in a straight line. What the men did, therefore, was to erect great screens of canvas, and at the top they put smooth oilcloth. Now, the locusts cannot climb over anything smooth. So here were the great screens of canvas with oilcloth at the top ready for them.

When the locusts appeared, they began to climb up the canvas, but on reaching the oilcloth they fell back, and crawled along at the foot of the screen until they tumbled into deep pits, which had been dug every few yards at the side of the screens. The pits were lined with polished zinc, so that, once in, the locusts could not get out, even if the weight of thousands and thousands of others falling on top had not prevented them. The men used 500,000 yards of canvas and dug 26,000 pits, and the result was that in the first year they caught 214,000,000,000 locusts, and in the following year 56,000,000,000 locusts. It cost more than $125,000 to do the

work, but the money was well used. Locusts have now vanished from Cyprus. But supposing that these measures had not been taken, there would soon have been enough locusts in Cyprus alone to destroy the crops of any country to which the descendants of these swarms had flown.

There is a striking difference between the grasshopper and the kind of locust we have described. The locust has its ears under its stomach, while the ears of the grasshopper are placed at the sides of its two front legs. The locust makes its loud chirp by rubbing its rough spiny wings one against another; so do the grasshoppers and crickets. Only the males do this, however, for the females have no means of making this noise. The noise that these male insects make is their way of calling their mates to them, and the females give the best replies by going themselves to answer it.

It is evident to most of us that crickets and grasshoppers and locusts belong to the same order, but who would think that cockroaches are of the same family? The cockroach is that big, fat insect which many of us call the black-beetle. It is not a beetle, but is a member of the winged order called Orthoptera. It has, like the cricket, two pairs of wings, the outer ones of a horny character, and acting rather as a shield for the others than for the purpose of flight. The under pair, however, are excellent wings, though the cockroach runs so fast with his six legs that he rarely has need to fly.

THE STRONG JAWS OF THE EARWIG THAT BITE AND SPOIL OUR FLOWERS

In this respect it is matched by the earwig. Some naturalists say that the earwig will not readily eat the flesh of its kind, but that is not the case. If an earwig be killed at night where many earwigs assemble, in a few minutes the dead body will be surrounded by half a dozen other earwigs, all eating away as if there were nothing else in the world for them. The earwig does not come so much into our houses as the cockroach does; it is usually to be found among our flowers. Dahlias are its special favorites, though nasturtiums will always attract it. Its sharp jaws enable it to bite pieces out of our finest blooms, while the insect may generally be looked for in any pear or apple which a bird or wasp has attacked.

The mother earwig is a really affectionate parent, and "mothers" her little ones like a hen. We must all have noticed how quickly an earwig drops to the ground if it is alarmed, or if it wishes to get quickly to the floor from the ceiling on which it is resting.

THE EARWIG'S BEAUTIFUL WINGS THAT WE RARELY SEE

There is no reason why it should fall, except that it knows that its horny covering makes it safe to do so. It has the most beautiful wings folded away under the wing-covers on its back. It is quite a task to get them unfolded and then folded back again in their proper position. The wings are not shaped like those of the cricket and grasshopper, but are more fan-shaped. The pincers, or forceps, which the earwig carries help it to fold up the wings again. But those forceps can nip too.

The story about earwigs getting into our ears is all nonsense; and that brings us to another absurd fable which terrifies very many people. Men and women who are otherwise well educated are so foolish as to believe if they hear a certain ticking in the woodwork of their houses, or their furniture, that it is a warning meant to tell them that a death is about to occur in their houses. An instant's serious thought should show how impossible the thing is; but as they cannot see what causes the sound they hear, and as people have for ages and ages believed the same thing, they go on believing the story to-day.

THE STRANGE TICKING SOUND OF A LITTLE BROWN BEETLE

What is the fearful "death-tick" or "death-watch"? It is a sound made by a little wood-boring insect with a stupidly long name—the *Xestobium tessellatum.* It is simply a rather fat red-brown beetle which bores its way into the woodwork of our furniture, tunnels through and through it, eating the wood which it bores, and ruining the furniture just as fast as it can. It has a thick, horny head, and the so-called death-tick is the beetle calling to its mate, as the cricket calls to his.

But instead of rubbing legs or wings, the beetle bangs his silly little head on the wooden floor of his tunnel, and that is the way he signals. Generally he knocks four or five times, then is still. Men have kept these insects at various times, and tried to make them utter their signal in the open, but without success, until one man chanced to knock gently with a pencil near the box in which the beetle was kept. Instantly the beetle thumped away with his head. And if we capture one of them and gently tap four or five times so that the beetle may hear, we can have

as many "death-warnings" as we like, whenever the beetle is not asleep or too busy feeding.

The beetle that we have been discussing is one of a family of insects which make their way into woodwork. They are as great a nuisance on land as the wood-boring worms are in the water. All the holes that we see in what we call worm-eaten wood are caused by these little pests.

THE FLY THAT SPOILS THE MILK AND SPREADS DISEASE INDOORS

We need not leave the house to discover one of the greatest of pests, the fly. The only thing that can be said in favor of flies is that they are good scavengers out of doors, eating up all sorts of horrible refuse which would otherwise make the atmosphere foul. But in civilized countries we ought not to depend upon methods such as prevail among savages. Flies carry disease to our food. When they are most abundant, in the latter part of the summer, they poison milk and other food which little children take, and cause many deaths. Indeed the wise men of one big city where there are many poor people, came to this conclusion—that it would be cheaper for the city to provide, at its own cost, pure milk which flies had not corrupted, than to bear the cost of all the funerals of little pauper children whose deaths had been caused by dirty habits of the flies.

Nothing is too bad for a fly to eat. It settles upon poisonous refuse, then flies off with parts of the poison adhering to it into a house, and there settles down on food, leaving corruption wherever it goes. The eggs of the common house-fly are laid in unhealthy refuse, where the grubs hatch and feed.

LITTLE FLIES THAT ARE OLD AND BIG FLIES THAT ARE YOUNG

Then they pass into a chrysalis stage, and eventually issue as perfect, full-grown flies. When we see flies of different sizes, we must not imagine that one is a young fly and another an old one. They are all fully grown when they leave the chrysalis. We have two or three kinds in our houses. One of them, the one which really bites, does so to suck our blood. It is called the stomoxys, and is a small black fly that does not appear until the autumn. The flies which we see hanging swollen and dead about the house have been killed by a fungus which attaches to them. This fungus eats its way into the body of the fly and kills it, and then spores drift off to become attached to other flies.

The bluebottle, which we almost forgive for its bright coat and breezy hum, is a dreaded enemy of the larder. It deposits its eggs upon flesh, or in wounds of animals, and there the eggs hatch and the larvæ feed.

We cannot name all the flies, for they are numerous. We must, however, not overlook the dreaded tsetse fly. This, though it may bite man, does not cause him any serious harm, but its bite is certain death to horses, oxen, and dogs. It lives in certain districts in Africa, and is supposed not to stray beyond them. It is noticed, however, that if anything occurs to disturb the wild animals and to send them afield beyond the places which they ordinarily inhabit, there the tsetse fly is also discovered. It has been suggested that all wild animals near human habitations should be killed so that the dreaded fly may be destroyed.

MEN WHO DIE TO SAVE US FROM PLAGUE CARRIED BY FLIES

As might be expected, there are innumerable varieties of flies in lands where we have heat and moisture prevailing in forest and swamp. South America and many parts of Africa are rendered almost unbearable by flies that sting and bite, while large areas in Italy—to name only one part of Europe—are the seats of disease and death every summer, as the result of winged plagues in undrained lands.

There is still much to be learned about poisonous insects, and many men are bravely devoting themselves to the work. Scientists have sacrificed their lives while studying these problems. They have gone into lands infested with deadly insects, and allowed themselves to be bitten so that they might trace the manner in which the disease begins, the insects from which it comes, and the manner of dealing with it. The story of these men is very sad but very wonderful. They are as brave as the bravest soldier that ever fought on a battlefield, for they fight, not to kill men, but to save them, and they lay down their own lives to save those of millions of people who may never hear of them or of the sacrifice they make. Naturally, where there is so much to be learned, the way to knowledge is difficult.

THE DOCTOR WHO LIVED IN A SWAMP TO STUDY A FLY

One of the worst diseases which afflict men who go to the unhealthy parts of Africa is called sleeping-sickness. When bitten by the insect which carries the particular sort of poison caus-

ing this disease, men become overpowered with a desire to sleep; all their energy and will-power go from them, and they die. A great doctor, Professor Koch, studied the problem. For eighteen months he lived by himself in the swampy regions round Victoria Nyanza, a lake in Africa, where poisonous insects teem in countless swarms. He believed that the disease was caused by the bite of an insect named *Glossina palpalis.* This insect breeds along the banks of the lakes and streams. It can be found from the source of a stream right down its banks running through hundreds of miles of country, spreading this terrible disease wherever it goes.

His experiments led him to a curious theory. He found that wherever there were crocodiles there also was the insect which caused sleeping-sickness. The insects, he said, live upon the crocodile in the first instance. They would seem to have a poor chance of biting these horny monsters. But they suck the blood between the armor-plates of the crocodile's hide. When a man draws near they fly off to him to suck his blood, and in so doing they inject poison into his system which in the end causes his death.

A DEADLY INSECT THAT RIDES ON THE MOSQUITO

THERE were places in Africa where the death-rate from malarial fever was so terrible that these places were called "the white man's grave." All sorts of beliefs as to the cause of these plagues were entertained. Many people thought that they resulted from poisonous fumes arising from the ground. But brave men risked their lives to solve the problem, and they found out what it all means.

They knew that death resulted when a man had been bitten by mosquitos, but they could not for a long time discover which was the deadly mosquito that actually caused the tragedy.

Among the men who studied the question in India was a brave young officer, Major Ronald Ross. He studied all the different varieties of mosquitos that he could discover. He took samples of the blood of men who had been bitten, and found in them a tiny organism which evidently conveyed the poison that caused death. But how did the organism get into men's blood? What had that to do with mosquitos?

After months and months of study he found that all the while he had been on the wrong track. The mosquito that he was seeking slept while he was awake, and came out to work its mischief while he was in bed. It was a night-flying mosquito. As soon as he discovered this, and examined the mosquito, he was rewarded for all his labors in examining other mosquitos, for here was one different from the rest. Upon its body he noticed a little parasite. A parasite is, as we know, a small animal living upon the body of a larger animal. This parasite was the origin of the poison. Like the ichneumon-fly, it lays its eggs in the body of the mosquito. These lodge in the poison-gland of the mosquito. When the mosquito bites a man, these eggs are forced into the wound caused by the bite, and there they develop and poison the man and cause his death.

It would be of little use to find the cause of death unless we were able also to find a remedy. Now, the life-history of mosquitos, gnats, and midges is very similar. The full-grown insects lay their eggs either in water, or in damp, decaying vegetation, or behind the bark of fallen trees. There they hatch and come forth as full-grown insects, ready to carry on the work of destruction.

Now, in many countries there is very little attempt at proper drainage. Stagnant pools lie about in the streets; rubbish collects in the villages; dirty old tins and cans lie about with water in them; water-butts are uncovered; there are a thousand places in which the deadly insects can be reared. Therefore, it became evident that if men, women, and children were to save their lives from the attacks of the insects, they must be clean in their habits.

DEADLY INSECTS THAT COMPEL US TO OBEY THE LAWS OF HEALTH

THEY must allow no pools of water to collect in their streets; they must allow no swamps to remain undrained near their cities; they must have no water-tanks open, or if they are open, then petroleum must be poured into the water to kill the insects there.

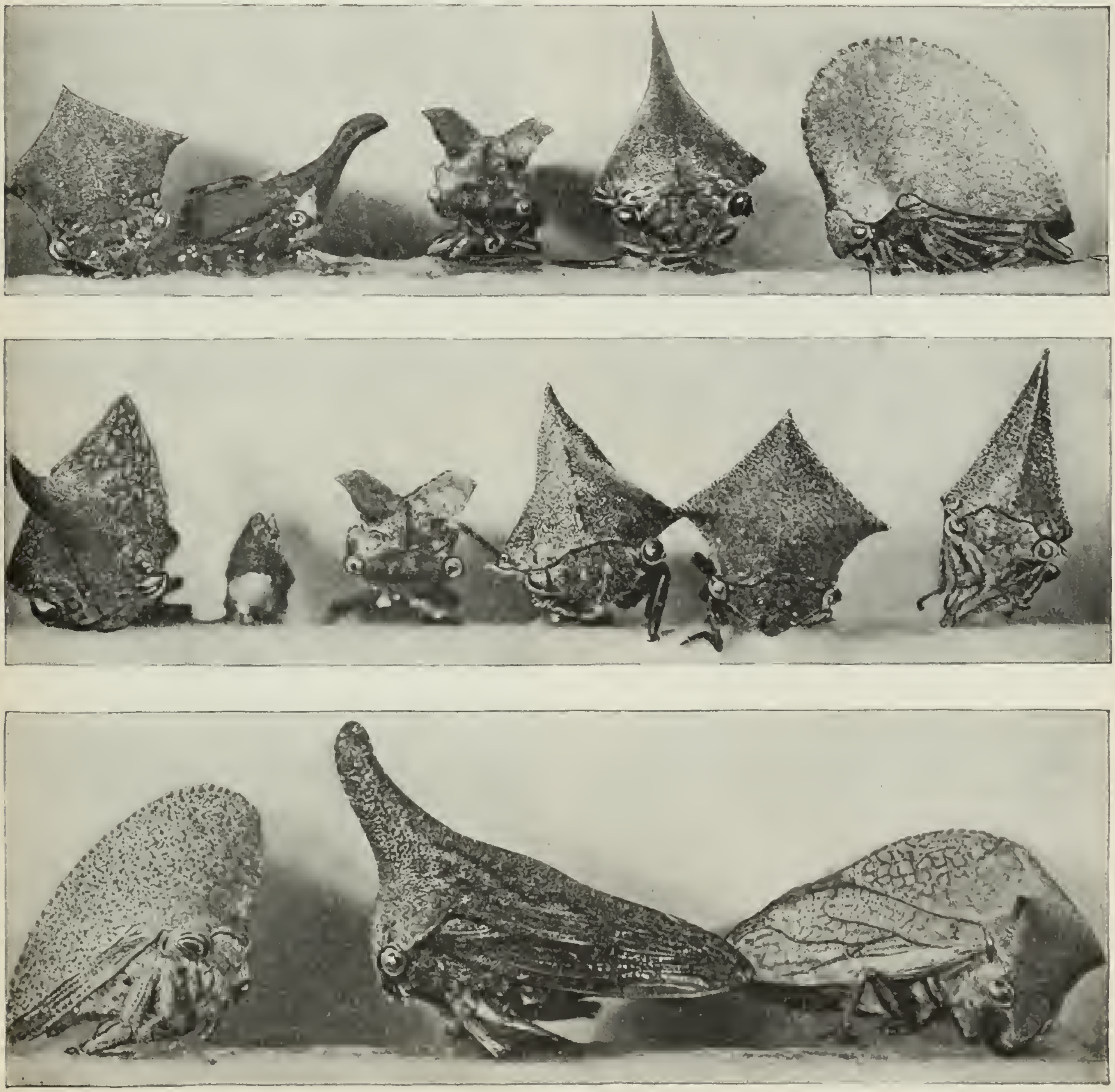
These horrid little insects, for whose existence it is almost impossible to find any excuse, might seem to have been sent by Nature to teach men to be clean. Towns which had been hot-beds of disease became absolutely healthy when the new rules were enforced. Death had been frightfully prevalent among the men who are building the Panama Canal, because of the bites of mosquitos. Our government sent skilful, determined men to carry out the work of making men clean and careful.

The stagnant pools were dried up; all rubbish was burned; no place was left in which the mosquitos could lay their eggs. And the result was that yellow fever and malaria, which the mosquitos had previously caused, both disappeared.

The same thing can be done for the health of people in the deadliest climates. If they will only attend to the laws of health, they need not fall victims; if they neglect them, then they fall victims to the insects which carry certain death. The same law applies to horrible parasites which afflict human beings.

LUDICROUS FORMS OF INSECTS

WHEN I first glanced at these photographs, which were sent to me by a friend, I thought that he had been carving odd-looking objects to amuse himself, and that he had concluded to amuse me. But another look showed that they are greatly enlarged pictures of the insects known as treehoppers, because some of them can make such prodigious leaps. They are half an inch or less in length, yet some of the relatives of those shown in the pictures can jump six feet. If a man, in proportion to his size, could spring like that, he could make a standing leap of about four hundred yards. They are abundant on the trees, bushes, and grass, especially of Brazil and of other warm countries. Their relatives in our own country are peculiar in shape, but none are so strangely formed as are those of the tropics, in which the upper part of the body, the "pro-



A SELECTION FROM THE MANY LUDICROUS FORMS OF TREEHOPPER INSECTS.

thorax," is so prominently developed, and takes so many fantastic shapes, that they become the queerest-looking insects which nature has produced.

It is supposed that the enlargement of the back is intended to give them some resemblance to certain parts of plants, such as thorns and galls. Their enemies, mistaking them for growths that are not good to eat, pass them by without attacking them. The hoppers themselves live among the leaves, and drink the juices of the plants.

In the summer, in the eastern part of the country, one or more of the common forms of these misshapen little creatures may sometimes be found.

HOW NATURE USES TINY INSECTS TO PUNISH CARELESS FOLK

Many unpleasant things, which we need not discuss, live upon the bodies of human beings if human beings are not careful. There is a parasite for everything. Animals have theirs, poultry and birds have theirs, and man has his. Man, with his superior sense, can avoid them if he will. All that he has to do is to keep himself perfectly clean and he will escape; or, if he is temporarily attacked, then he must take the proper course to rid himself at once, and all will be well. If he will but keep himself clean, he can keep himself free; if he does not, then he must pay the penalty. Nature has no mercy for the careless or the unclean.

A gnat is a mosquito and a mosquito is, of course, a gnat. Those that have feathery, plume-like antennæ are harmless. These are the males, which live upon vegetable substances. Those that have not the plume, but sit, when at rest, with the hind legs upturned, are the females, and the ones that bite.

It is the female midge, too, which bites, not the male. Midges are smaller than the gnat, and, when examined under the microscope, are really beautiful little things to look at. But they are better dead than alive, for their bite is most painful. Like the mosquito and other blood-sucking insects, they have the most wonderful tools for their work.

THE LITTLE MIDGE WITH A LANCE FOR CUTTING AND A PUMP FOR SUCKING

They have barbed lances for cutting and sawing, and little pumps with which to suck the blood. How it is that they cause such pain is not quite clear. Some men think that they squirt into the wound that they cause a little drop of poison to make the blood thinner and more ready to flow. The fact is, however, that, except in a year of many midges, we think so little of them that we do not bother to examine their ways. They affect people very differently. Upon some they make merely a red spot; upon others they raise huge lumps, so big that, if the bite be upon the face, the whole eye may be closed until the effects of the bite disappear.

We ought to feel very thankful that the horse-flies do not often attack us. They are the great gray-bodied creatures which hum so loudly as they fly. They do not often bite men, but when they do they show the most alarming intelligence. They settle upon the back or shoulders, so that they may bite and not be immediately perceived; and so powerful are their tools that they can pierce thick clothing, and so reach the flesh beneath. Horses they attack by settling where the animals will be least likely to reach them with their tails.

The list of insect enemies is far from exhausted. There is a terrible array of them in the garden. Those that we have been writing of now, however, suffice to show how very careful men have to be to guard their health and property from the lesser animals of the world.

THE BEETLE WITH A FUR COLLAR AND A STRANGE "FACE"

A beautiful brown-and-gray beetle on a branch of an evergreen tree had attracted the attention of an observing man, who brought it to my desk

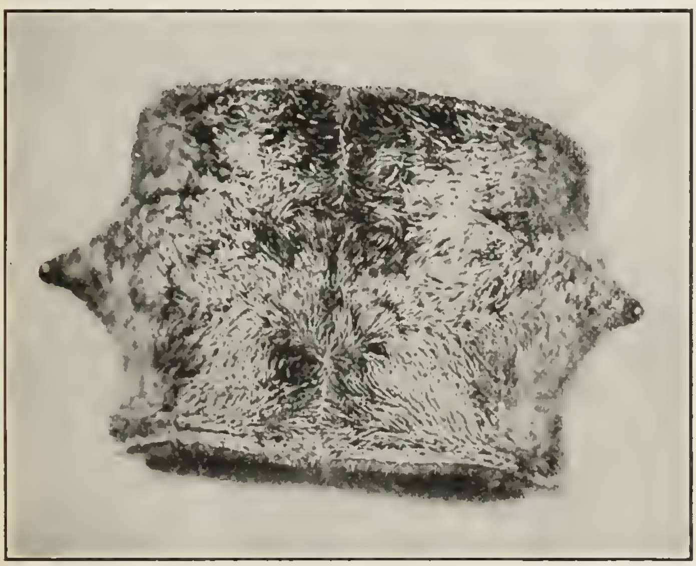
THE BEAUTIFUL BROWN-AND-GRAY BEETLE.

to learn, "What is its name and how does it live?" The name, *Monohammus confusor,* I explained, is a little longer than the beetle itself,

which is only an inch and a quarter in length. The larva bores in the wood of pine and fir.

A FACE SUGGESTING THAT OF A COW.

To show to the best advantage the beautiful brown-and-gray furry covering, I placed the beetle under a small pocket-lens, that brought



"THE FUR COLLAR."

forth the astonishing exclamation, "Why, he has a fur collar, and his face looks like a cow."

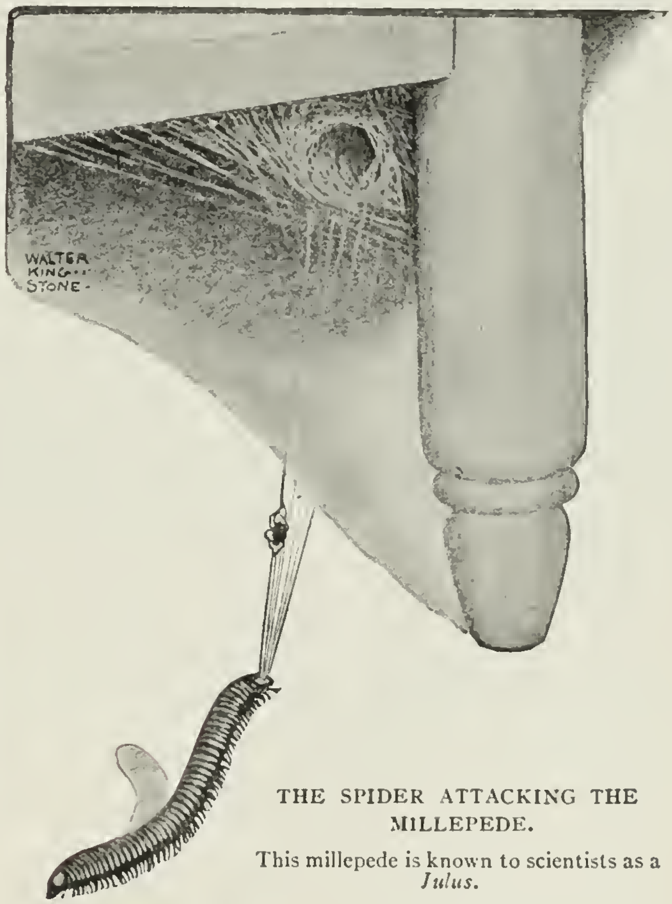
I did not dispute, but merely wondered whether our boys and girls would agree with him. Of course I cannot pass the beetle to all of you, so I do the next best thing, and photograph it a little enlarged, with a separate picture still more enlarged of the face and the collar.

Was the visitor's jocose exclamation properly descriptive of what he saw?

A LILLIPUTIAN ENGINEER

As I sat in my log cabin, awaiting the long-anticipated dinner-horn, I noticed a commotion, at the foot of my washstand, in the strong sunlight that streamed across the floor.

A house-millepede, or "thousand-legger," crawling over the lighted space, had been seen by a tiny spider, whose lair was attached to the leg of the stand, a foot above the floor.



THE SPIDER ATTACKING THE MILLEPEDE.

This millepede is known to scientists as a *Julus*.

The spider was so small that her body was not much larger than the head of a common pin, while her legs were too short to be seen from where I sat.

Like an arrow the little creature darted down an invisible thread, and, quickly touching the crawling millepede, returned like a flash to her silken home above, only to repeat the operation again and again, each time spinning a thread finer than the finest silk, and fixing it to the body of the intruder.

The millepede stopped crawling, and by thrashing its body to the right and the left did its utmost to break the silken lines. Regardless of these struggles, the spider advanced again and again, each time adding a freshly spun thread to the victim's body.

Then the millepede changed its methods, and, instead of throwing the body first to one side and then to the other, began to crawl backward, using its entire strength in attempts to break the cords that held it. The spider, like an animated speck, wove the web and strengthened the lines unceasingly. By looking closely I could see that in some mysterious way the gossamer threads were actually drawing the captive off the floor.

The millepede was now desperate, and, clinging with its hindmost feet, it swung the front part of the body free from the ground, and made frantic efforts to break the threads.

A bee never worked more industriously than that little spider. She, like myself, was expecting her dinner, and, unlike me, was working for it industriously.

The millepede was now relaxing its efforts. The many feet were gradually leaving the floor; only two or three seemed to be holding fast, when suddenly, and strange to relate, the "thousand-legger" swung clear, and, through some unseen agency, was lifted inch by inch until it reached the very web itself. The spider then swiftly wrapped it in a sheet of silk, and the captive struggled no more. The spider, although only perhaps a thousandth part of the weight and size of the house-millepede had succeeded in capturing it and in actually lifting it bodily to her lair!

For a child to throw a lasso around an elephant's neck, and then, climbing a tree, to pull the elephant after him, would not be more wonderful than was the work of this little spider that captured the comparatively gigantic "thousand-legs," and lifted it up to her den.*

CHARLES CRISTADORO.

SOME INSECT FRIENDS

THERE was once a stupid fellow who saw a toad, one of the best friends of the gardener.

"Toad, are ye? I'll learn ye to be a toad," he said, and brought down his spade, whack! on the poor toad's head. That is just the sort of thing that ignorant people would do, not only with toads and reptiles of every kind, but with all sorts of insects as well. We know that certain insects are harmful to man; but let us be fair and look at the case of those which are our friends.

We will take in more than insects, too, for we will say a word for the humble worm, which is not an insect, as, of course, we know. Most people hate worms, and kill them when they can. Yet worms are industrious helpers of the farmer and gardener. Darwin studied their habits closely, and found that they help greatly in making our soil good and fertile. They eat the earth in which they live, just as the wood-borers eat the substance in which they make their homes.

The worms bring to the surface the earth which they have eaten. They make channels in the soil by which the air can enter and give the soil the nitrogen it needs for making it fruitful. They carry down pieces of grass and straw, and these help the process. But most important is their work in bringing to the surface soil which has been lying below. Darwin found by calculation that the worms on a single acre of land bring up ten tons of dry earth to the surface every year.

Some savage peoples are really far wiser observers of Nature than we are. They realize the value of earthworms. When a native of the Yoruba country, in Africa, decides to cultivate new soil for a farm, for what sign does he look? He looks for the evidences of earthworms. Probably he has never taken the trouble to reckon up how much work the earthworm actually does. He cannot go into figures as Darwin did. But he does know that the earthworm makes the soil good for crops. So if he sees that worms are at work upon a tract of land, it is there that he sets to work to farm. If the land lacks worms, he knows that there is no use in his attempting to farm, and he goes farther afield until he does find them. Probably few people who are interested in evidences of past civilizations think that they owe anything to worms. But they owe a very great deal. Those beautiful tessellated pavements which the Romans made in Britain have been preserved for us almost entirely by worms. They covered them with soil, in which they have been secure for a thousand years. But for the worms these precious relics of the past must long ago have been destroyed.

The most charming of all the things which bear the name of worm is a creature which is not a worm at all—the glowworm. The glowworms, as we call them, are really beetles, and do us good service by entering the shells of snails

* The so-called millepede (thousand feet) has only about one hundred feet or legs. Our common centipede (hundred feet) has about fifteen pairs. So you see that the people who first named these interesting little animals greatly exaggerated or else did not make careful count.—ED.

and devouring the occupants. Naturally, they move about at night, or they would not need the wonderful light which they are able to produce.

THE MARVEL OF THE GLOWWORM AND ITS WONDERFUL LAMP

The light is phosphorescent, and is produced from fatty cells, to which run many tubes carrying the oxygen necessary for the light. The operation of this light is as wonderful as the operation of the batteries of the electric fishes. The rays of light which the glowworm gives off are said to possess the same properties as the famous X-rays—they will pass through solid substances through which the eye cannot see. Men can produce light by gas and electricity, of course; but they cannot do as the glowworm does—produce light without heat. This humble beetle has a power which man cannot imitate.

All the energy that it uses goes to making light; none is wasted in heat. The male glowworm has wings, and flies about on summer nights, showing his light frequently, but for short intervals. The female has no wings, but shows her light to attract her lover. He is delighted when he finds her; but she is very heartless, and when he arrives she continues to flash forth her light to attract other males, so that she may have a number of them buzzing about her to sadden the heart of the first arrival, her real sweetheart.

The powers of the light given forth by the glowworm are very great considering how small the beetle is. Placed in the dark, the glowworm yields a light strong enough to enable us to read print by it, or to tell the time by a watch. There are hundreds of species of this beetle and other light-giving beetles.

THE FIREFLY THAT IS REALLY A BEETLE AND LIGHTS UP THE FOREST

The fireflies, like the glowworms, are really beetles. In many parts of our own country, in the West Indies, in South America, in some parts of Canada and of the Orient, the forests at night are like dreamlands or fairy worlds. The fireflies wing their way in countless swarms around the trees, lighting up the foliage as with gleaming diamonds. After rain the air seems filled with trains of flashing stars, waving about the tree-tops in glowing circles, making the scene such as might inspire the mind of poet or painter.

These wonderful creatures have their real use, as well as beauty, for the traveler. Men who would not dare to pass, unlighted, through the forests at night attach fireflies to their boots to light the path they tread. Thus lighted, a man goes on his way as in daylight, and when the sun gets up, he gratefully replaces his living lanterns on a shrub so that they may live to serve others in the same way.

Certain birds use the fireflies to light their nests. Natives of some lands make lanterns of them. Spanish ladies wrap them in gauze, and use them as ornaments for their hair; and young people sometimes decorate their dresses and the harness of their horses with them.

A LITTLE FLY THAT FIGHTS FOR MAN AND SAVES OUR GARDENS

We must leave these beauties, however, and pass to another noted family which is famous, not for its beauty, but for its service to man. This is the family of ichneumon-flies. There are thousands of species, and it is safe to say that men engaged in agriculture would be helpless without them. They lay their eggs in the bodies, or even in the eggs, of harmful insects, and so destroy these while multiplying themselves. The female has what is called an ovipositor. This is a sort of combined spear and tube. With the spear she makes an opening in the body of the insect in which she is going to deposit her egg; then, having made it, she produces an egg from the tube, and leaves it in the victim's body. Sometimes an ichneumon will lay its eggs in the body of another ichneumon, but generally they choose other insects, and keep each to its own class of victims. Let us watch one at work on a rose-leaf.

BATTLE FOR LIFE BETWEEN INSECT PESTS AND FRIENDS

Although the aphides make very good cows for the ants, they are terrible enemies of our rose-trees, whose leaves they spoil by robbing them of their life-juice. Down comes an ichneumon-fly. She walks on her high, stilt-like legs, over the leaf until she sees a plump aphis. She touches it with her antennæ.

If the aphis were thus touched by an ant it would quickly produce some honey, but now it knows that a deadly enemy is at hand. It begins to wriggle violently to escape the doom which instinct tells it is near. The fly may wait until the aphis has finished wriggling, or may even give up and go to another victim. But in the end she is successful. One thrust of her lance in the back of the greenfly's neck makes the

nest of the egg. In that wound the egg is placed, and the ichneumon, having fifty or sixty such eggs to place, hurries on elsewhere to continue her task.

The aphis does not die. It knows what has happened, and, leaving its companions, crawls away to a leaf to be all by itself. Presently the egg hatches, and the grub which leaves the cell lives upon the flesh of the aphis. We can only hope that the latter feels no pain. It seems a dreadful story, but naturalists suppose that the aphis suffers a sort of paralysis, which mercifully prevents it from feeling discomfort.

THE TINY FLY THAT KILLS THE FOES OF THE COTTON-PLANT

When the grub has reached a certain size, the aphis dies. Then the grub makes its way out of the dead body and spins a silken cocoon in which it undergoes changes, and finally comes forth as a winged ichneumon-fly. In that stage it lives upon the juices of certain flowers, and in its turn goes out to find aphides in which to deposit its own eggs. But for the ichneumons, men would be helpless against the attacks of caterpillars, greenfly, and other things of the same sort. The blessing is that they make their attacks upon insects which are among the most numerous in the world, and from which we suffer most injury.

There is a very important ally of the ichneumon-fly of our gardens called the chalcid-fly, a fly of many species. The cotton-plant has terrible insect enemies, and the chalcid-flies are the only things to keep them down. The chalcid is no match for the fully developed insect, but scientists have found that it destroys millions of the eggs of these larger insects, and so saves the cotton-plant from being ruined by the grubs which would issue from the eggs if the latter were left undisturbed.

A FLY THAT HAS CROSSED THE OCEAN TO MAKE POOR FRUIT RICH

Another thing that one of the chalcid-flies does is to give to California figs which now rival those of Smyrna. Smyrna figs have been from early times the best figs in the world. Farmers in California bought trees from Smyrna, and made them grow in California, but the fruit was not the same. Clever men of science studied the problem and solved the mystery. They found that the Smyrna fig-tree is the home of a chalcid-fly which, with its saw-like weapons, cuts into the fig-bud, and so introduces pollen which makes it big and sweet and rich. Chalcid-flies were therefore placed upon the trees in California, and the figs grown there under these conditions are as good as those of Smyrna. Here, then, are two examples of the great value to men of some of the smallest of Nature's offspring.

The ladybird is another of our friends in this country. People have such a horror of anything called a beetle that it is just as well that the ignorant do not know that the ladybird *is* a beetle, or, in spite of its great work for us, it would be killed by the stupid. We like to pet the ladybird because it is so pretty and so fearless. But its real value to us lies in the fact that it eats the insects which destroy our plants. One species lives entirely on the aphis, the rose-pest; other species lives on those tiny animals which we call scale-insects—the insects that ruin hops and fruit-trees. The young ladybirds might be in danger of being killed if people did not see them devouring the plant-lice—they are so unlike their parents. They look like tiny crocodiles when they first begin to run about the leaves on which they have come from the egg. Soon, however, it is seen that they are hunting aphides, and then their mission is realized to be one of value. The full-grown ladybirds have to seek warm retreats in the winter, and it is then that many get into houses. They can be safely handled and examined. If they are roughly treated or alarmed they have the power to emit a yellowish fluid with an unpleasant smell.

HOW INSECTS ARE VALUED FOR SAVING CROPS

So valuable are the ladybirds that they are sent from country to country. A cargo was sent to California to destroy the scale-insects which were killing the orange-trees there. These were so successful that a cargo was sent from New Zealand to England to cope with the scale-insects which were multiplying on the hop-plants. Unfortunately this was not such a success. The climate of England did not suit the little visitors so well as that of their native land. They found the hop-plants too high for them, and refused to seek higher than three feet from the ground. Finding the work so unsuitable for them, they gradually forsook the hops and worked away at the scale-insects on the currant-bushes in nursery-gardens.

The beautiful dragon-fly is another of the creatures which are commonly misunderstood. It has a spear-like tail, and when threatened curls this up and down as if it meant to sting. This might frighten a larger enemy; it certainly

frightens ignorant human beings, who call it "horse-stinger" and kill it, when they can, in the belief that it is an enemy. They kill a very good ally by so doing. The dragon-fly, though it does not and cannot sting, is a sort of king of the insect world. It lives on other flying insects, and when we see it dashing about in the air like a flash of light, it is simply hunting prey which, if left, would injure us. Its powers of flight are marvelous, and it is impossible for a man even with a big, long-handled net to catch them when they are flying.

THE GORGEOUS DRAGON-FLIES THAT TRAVEL AS FAST AS TRAINS

The dragon-flies seem to know exactly what a pursuer means to do, and no matter how swiftly he may move, no matter how cunning he may be, they always manage to keep just out of reach of his net. They must be caught when at rest, if at all. It is the swiftness of their darting, swallow-like flight which makes them so certain of catching mosquitos and other insects on the wing. They can catch insects when flying at the rate of forty or fifty miles an hour.

To enable them to make their rapid pounces in all directions, they need fine eyesight. And they have almost, if not quite, the finest eyes in the insect world. Their nearest rivals in this matter are the butterflies and day-moths. Not only are their eyes big; they are compound, made up of an enormous number of facets, each of which is an eye to itself. The dragon-fly has practically from 15,000 to 20,000 eyes in each of its eyes, and through each tiny angle can see as clearly as we can see with our eyes.

It must not be thought that the dragon-fly is an exception in having these marvelous compound eyes. The point is that the eyes of the dragon-flies differ in degree of strength, not in kind, from the eyes of other insects. Nearly all insects have these compound eyes. Our common house-fly, for example, has thousands of cone-shaped eyes bound into one big cone-shaped eye, and each facet is a separate self-working eye, though part of the greater eye.

AN INSECT WITH 25,000 WINDOWS TO ITS BRAIN

The house-fly, as he darts across the kitchen or into the larder, has 8000 chances of seeing food or the cream-jug. The common beetle has 6000 chances of seeing something worth looking at, while the mordella-beetle has over 25,000 windows to its brain.

We must not leave the dragon-fly without a word as to the manner in which he came into the world. His life-story is similar to that of the mosquito. The eggs are laid in fresh water, and hatch there. The larvæ eat very hungrily, strong nippers in front enabling them to grasp and eat quite big insects and other forms of food. Their breathing is very curious. In a way it is like that of a fish. They have no windpipe or lungs, of course. The water enters the lower part of the body, where many little tubes extract from it the oxygen necessary to the insect's life. Then the water is forced out again, and the pressure of the water going forth is sufficient to drive the larva on its way without its troubling to swim by other means. When the time for a change comes, the larva crawls wearily up the stalk of a plant. He is feeling far from well. There he rests for a while. Suddenly the dull old coat in which he has been floating about splits down the back, and lo! a gorgeous dragon-fly creeps forth. He has wings now, small and damp and crumpled; he would be helpless if an enemy sought him. But he waits, and the sun dries him, his wings harden and expand, and very soon he rises into the air in all the majesty of four splendid wings, and with a coat of mail bright and shining as the mail that the knights wore in days of old.

THE BEAUTIFUL DRAGON-FLY AND THE HARMFUL GADFLY

Sometimes we hear the dragon-fly called the gadfly. There could not be a greater mistake. The gadfly is another name for the bot-fly, one of the greatest enemies we have. The horse-bot lays her eggs on the hair of the horse, in some place where the horse will be sure to lick itself. The eggs cling to the tongue of the animal and are swallowed. They remain in the stomach of the horse all the winter, and, leaving the body of the horse in the spring, burrow into the ground, and there become flies.

The ox-bot is more generally known as the warble-fly. This horrible creature serves the cattle as the ichneumon-fly serves the aphis and caterpillar, boring a hole in the hide and laying its egg there. Cattle are terribly afraid of the warble-fly, and will sometimes gallop themselves to death to escape it.

The sheep-bot is the worst of all, for this crawls into the nostrils of the sheep and lays its eggs there, where the grubs, on hatching, sometimes crawl into the brain of the poor sheep and kill it. These are the gadflies, so we must never

again confuse our gay friend, the dragon-fly, with them.

The dragon-fly and the mosquitos are by no means the only insects which undergo such surprising changes, being born in water, to fly in the air. The same course of life is followed by very many others with which we can afford to be on the very best of terms.

THE SNUG LITTLE HOUSE THAT THE CADDIS-WORM BUILDS

The caddis-fly, for example, deserves a chapter to itself, could we spare the space. The eggs hatch in the water in which they are laid, and the grubs are called caddis-worms, which fishermen are only too glad to secure for bait. They make the most wonderful nests for themselves in which to pass their days under water.

They gather bits of sticks and leaves, grains of sand, and tiny fragments of shell, and cement them all together to make the snuggest of houses. Some cut leaves and twigs into short lengths, and cement them together to form a tube. Others build up a home made of shells, in which the little animals to which they belong are already living, and the living molluscs are fastened round to make a live belt or shield for the caddis-worm.

Inside these tubes the caddis-worm spins a a robe of silk which leaves its tail covered, but permits its head and legs to come out, so that the larva may collect its food of vegetable or animal substance. When they are to undergo their change, they close up this front door, either with plates of silk or with stones, so that the water may come through, but not animal enemies. Before the great change quite arrives, the larva must come out again, quit its cell for ever, and climb up on to a plant, where its shell will split open and it will appear as a pretty winged insect, the caddis-fly proper.

MAY-FLIES THAT LIVE LONG IN WATER AND ONE DAY IN AIR

All this discussion of insect changes must have made us think of the life of the May-fly, or day-fly, as it is also called. The story of its life in the water is similar to that of the other insects of which we have been reading. But here the life in the water may last for two or three years. In that time the larva lives a busy life, hunting and feeding on other insects, making itself dwellings in the sand or mud, and slowly, very slowly, preparing for the time to come. Finally, the great day arrives; the pupa stage has been passed, and the insect climbs out of the water all ready for flight, except that it is still wrapped in its pupal robe. This has to be worked off, and then the May-fly mounts into the air. The flies may be seen in millions and millions on a summer evening, dancing and eddying in the warm air over canal or pond or stream. Their lives in the air never last more than a day. Often only an hour passes between the time of their leaving the water and their death. In that short time the females lay hundreds of eggs on the leaf of some water plant. Then they die. Their life in the air has begun and ended in, perhaps, an hour, after they have spent years in the water preparing for it; and at the end of that hour their dead bodies lie in such multitudes that they may be swept up and strewn on the fields for manure.

THE CUNNING ANT-LION THAT DIGS A PIT FOR ITS PREY

It is to this order of insects that one of the most extraordinary, the ant-lion, belongs. After it has undergone its change, the ant-lion becomes a pretty fly, but it is while in the larva stage that it most interests us. It makes a pitfall in which to catch its prey, and this is the way in which it does it: selecting a dry, sandy spot, it first marks out a circular furrow; then it places itself in the center, and, half burying itself in the sand, it begins to dig. It uses one of its legs as a shovel; with this it throws up the sand on to its head, with which it jerks the material out of the circle and beyond the furrow. In the cleverest way it thus makes a tunnel down into the ground, funnel-shaped, two or three inches wide at the top, and narrowing down to the bottom.

When the work is finished, the ant-lion practically buries itself in the sand at the bottom of the pit, and waits, listening, for an insect to come along. Presently, down topples an ant or something else; the ant-lion springs from its hiding-place, and, seizing the victim with its strong jaws, holds it until it has sucked all the juices from its body; then it throws the body out of the pit and waits for more. Should the prisoner be skilful enough to escape from the ant-lion and start to crawl up the side of the pit, the ant-lion at once flings up sand or earth with its head, and so causes the runaway to fall down again.

THE PRAYING-INSECT THAT HELPS MAN BY KILLING INSECT PESTS

We turn now to another famous insect, the praying-insect, or praying-mantis, as it is called

Though they can fly, insects of this kind do not pursue their food on the wing. They wait on trees or shrubs till a victim draws near. The head is bent down and inward, the long, powerful front legs are folded and held up as if the creature were praying. But the instant a fly or other insect draws near, the big front legs shoot out and seize it, and down the throat of the mantis it goes. We must regard it as a friend of man, for it kills and eats a great number of injurious insects. There is one species of mantis in India which is most wonderfully colored, so that when it rests it looks like some gay orchid. Insects approach it believing it to be a pretty flower, and are at once seized and gobbled up.

HOW THE DEVIL'S COACH-HORSE SLAYS A CATERPILLAR

Going to the opposite extreme we come upon the up-curving body of a very fierce-looking beetle. We point a stick or a finger at him, and he opens his strong jaws and curls up the back part of his body, and looks ready to fight. And so he is. He is the big rove-beetle, which we call the devil's coach-horse. For all his black, ugly body and threatening looks, he is a prime favorite with all gardeners who study natural history.

His appetite is as big as his courage. The devil's coach-horse will attack any insect, no matter how big. With a snap of its great jaws it will cut caterpillars or earwigs in half, and make a meal of them. Snails and slugs are among its dainties, and it will eat any carrion which it may find. The devil's coach-horse belongs to a big family of rove-beetles.

We have read so much about eggs deposited in the bodies of live creatures that we may turn now to beetles which choose dead bodies for the purpose. These are the famous burying-beetles. We never see them unless there happens to be a mole or mouse or some other small animal lying dead in the garden. Then they come up as if from nowhere, husband and wife, busy as can be, and claim the body as if they had bought and paid for it. Folding their wings, they at once begin to dig.

If the soil on the spot is not of the right sort for their work, they drag the dead animal to some place more suitable. To do this requires extraordinary strength in beetles, but they have very powerful jaws. The digging begins with a circular furrow like that made by the ant-lion, and then another is made within that. They keep digging away until the body begins to sink. When it has sunk far enough they throw over it the earth which they have excavated. Then they feast upon the body, and the female lays her eggs in it, so that when the larvæ hatch they shall find food ready at hand. Then off they go again.

Of course, these are not the only beetles to bury things. The sacred beetle of Egypt does it, too. This beetle, whose proper name is the scarabæus, belongs to a numerous family. It collects refuse, makes it into a ball, and rolls it into its hole in the ground. There it feeds untiringly, for a fortnight at a time, without resting, until the mass is gone. In other balls of refuse it deposits its egg, and from this, in due course, the young scarab issues. The Egyptians used to think that the old scarab died on entering the ground, and that the young scarab was the same beetle resurrected. Many other silly traditions of this sort came to be associated with this beetle, and it was as sacred to the Egyptians as the ibis. They worshiped it while it was alive, and after its death embalmed it, just as they embalmed their own monarchs. And yet it is only a scavenging beetle of very unpleasant tastes.

Returning to our garden again we must say a word for another beetle or two. Nearly every one that we find there is a friend, living upon injurious grubs and insects. The tiger-beetle and the violet ground-beetle deserve special mention as among helps of the gardener. The tiger-beetle has about a thousand species, but the majority of them are in hot lands. Many are pretty and active, and possess great jaws and powerful wings. They live entirely on insects. The list of friendly insects is far from complete. There are, indeed, thousands and thousands of different sorts of insects that are harmful to us, and there are probably just as many that help us. We can all extend our knowledge by watching the daily lives of the insects around us in our gardens and elsewhere.

THE BUMBLEBEE

BY BARNEY HOSKIN STANDISH

THIS chunky, hairy, noisy fellow is king of the cold. He stays with us summer and winter, and is said to prefer the Arctic region to the tropics. I do not doubt this, for he will sleep out of doors any cool night of spring or fall without asking for an extra blanket. Indeed, he is homeless for nine or ten months of the year, lodging wherever night overtakes him, on a blossom, a leaf, and even upon the ground. If he has any choice in the matter I think he prefers the thistle, where the spines are thickest. Perhaps he is aware that these stingers will guard him from the skunk and the snake while his own are in a body stiffened by cold and drowsy with sleep.

There are three kinds of bumblebees reared in a nest: queens, drones, and workers. The queens alone survive the winter. They apparently spend the first few weeks of spring waiting for red clover to bloom, the first blossom of which is the signal for nest building. Before this they visit the willows, hum a soft bass about the lilacs, thrust their long tongues into the honeysuckles and grow fat at the exhaustless honey-jars of the waterleaf, and then the play-day ends and labor begins.

Nest-building with them does not mean nest-construction. One bee alone could not well do that; besides she is in a big, bustling hurry now; she has actually seen a clover-blossom. Out and in among the dead, matted grasses of last year's growth she goes, hunting perhaps for the abandoned nest of a field-mouse. It will be remembered that these little animals build upon the surface of the ground soft nests of grasses, in which they winter. From these they have runways leading in different directions. The bee goes down into the dead grass, scrambling on as best she may, until she finds one of these runways, following it up to the nest. If it is occupied, she goes elsewhere; if not, the mouse-nest straightway becomes a bee's nest and the little creature begins her preparations for housekeeping.

She now collects a mass of pollen in which to deposit an egg. As the egg hatches and the baby bee grows she keeps this mass moistened with honey, and he helps himself, eating out a cavity larger than a white bean. In this he spins a complete cocoon. When this is done

he takes a long nap, in which he changes from a grub into a bumblebee, with wings and legs. Meantime the parent removes the thin coating of pollen from the upper half of the cocoon and apparently spreads a yellow secretion, or varnish, upon it, as if to keep out moisture. She is also now busy collecting more pollen and laying eggs in it and constructing a rude cell or two in which to place honey, as if for a rainy day. The first bees that hatch are worker-bees, and at this time are downy, pale, and baby-like in appearance, and behavior. In later summer, queens and drones are raised.

Recently, I watched a nest carefully, from June first, the day of its foundation, to its abandonment in mid-August. In it five broods were reared, each one like its predecessor, only more numerous. No eggs were laid in cells, as is the case with the honey-bee, and no cells from which bees had hatched were used again for brood. A few of them were used for honey, and a few for pollen; but they were usually cut down and removed to make room for the new brood, which was each time started in a pollen-mass, making cocoons side by side.

It has often been said that these cells are made of wax. Careful experiments tend to prove that there is no wax either in the honey-cells made by the bees, or in the cocoon-cells made by the larvæ. In other words, the bumblebee does not secrete wax. If we compare its conditions and surroundings with those of the great wax-producer, the honey-bee, we shall see how unlike they are. The latter, while secreting wax, hang in masses, often of many thousand, as if to generate heat; cold effectually checks secretion. Now, the queen bumblebee starts her cells single-handed and alone, in an open house where the temperature may not be high enough during a single hour of the day for the secretion of wax. During the whole season she may not have a dozen assistants at one time. Her dark-colored honey-cells, therefore, are made of pollen grains dirt specks, and honey, apparently varnished within. The yellow oval cells are the cocoons made by the young bee, and apparently smeared with a yellowish secretion or varnish, in which there is no wax. Whether this secretion is produced by the larva for the fastening of its threads to the walls, or whether by the bees without, I have not determined.

The length of life of a queen bumblebee is probably little more than a year at most. Here is one reason for this belief. She hatches among the late broods of summer, and soon after leaves the nest, leading a vagabond existence, night and day, among the autumn flowers. The winter she passes in an earth-burrow dug by herself, and unaided establishes a colony in the spring. These combined periods of fall and spring require the daily use of her frail wings in the field at least four months. Now, we know that the wings of the worker honey-bee wear out in less than half that time; also that the old queens who take to the field after the nest breaks up in August frequently have tattered wings and soon disappear. Nature does not supply insects with new wing cells, as it supplies birds with new wing feathers. So the loss of the power of flight at this season of the year to the queen bumblebee means the loss of life.

The queen bumblebee has pollen-baskets and a sting, and if held in the hand will use the latter if possible; but she will desert both nest and brood before she will attack man in their defense.

Workers are the smallest bees of the nest, and they have both stings and pollen-baskets. When they begin to appear in the field in July the queens disappear from it until the young queens make their appearance. The life of a worker-bee doubtless is less than two months long, and its wings are subject to wear, like those of the honey-bee.

Drones are without pollen-baskets and are stingless; but they work on flowers and have capacious honey-sacks, which they freely empty as tribute when caught. On the thistles of autumn they are as abundant as young queens, but, as they do not survive the winter, their lives are, doubtless, as short as those of the workers.

The work of the bumblebee in bringing about the cross-fertilization of flowers is as important as that of the honey-bee, and these

two stand at the head of the list of insects useful in this respect. Each has its flowers which it alone visits, but there are many flowers on neutral ground, visited by both. So we may say of the bumblebee, as of the honey-bee, the more bumblebees the more seeds; the more seeds the more flowers—especially wild flowers, as the tall bellflower, touch-me-not, Solomon's-seal, gentian, Dutchman's-breeches, and turtle-head. But probably the most important work this insect does for agriculture is upon the fields of red clover. There is abundant proof that this plant will not produce seed without the coöperation of the bumblebee. It is impossible for the wind to bring about the fertilization of the seed, as it may do in the case of Indian corn, grain, and some forest trees. The tube of red-clover blossoms, too, is so long that other insects (including the honey-bee) are not regular visitants.

Here is proof that this plant must have visits from the bumblebee. This insect is not a native of Australia, and red clover failed to produce seed there until bumblebees were imported. As soon as they became numerous the plant could be depended upon for seed. Again, the blossoms of the first crop of the "medium red clover" of our own country are just as perfect as those of the second crop, but there are too few bumblebees in the field, so early in the season, to produce fertilization; hence little or no seed in this crop. If bumblebees were sufficiently numerous there is no reason why much larger yields of clover-seed might not be expected than at present.

Here is what a well-informed farmer says about it:

"It was formerly thought that the world rested on the shoulders of Atlas. I can prove that its prosperity rests on the bumblebee. The world cannot prosper without the farmers' product. The farm will not be productive without clover. We cannot raise clover without seed; and we cannot have clover-seed without the bumblebee, because it is this insect that carries the pollen from flower to flower, securing its development and continuance. Let us learn to know and to protect our friends."

THE BUMBLEBEE'S SONG

BY ANNIE WILLIS McCULLOUGH

This song of the bumblebee
He sings for you and me,
As he buzzes about the vine
Where the morning-glories shine:

"O good my little gentlemen, the world is all a-jumble
With pretty maids, and pleasant glades, and blossoms in the sun!
O good my little ladies, there is no cause to grumble,
The weather 's fine, the hour 's mine, the morning 's well begun!"

Thus singeth Sir Bumble,
With many a stumble,
As he buzzes about the vine;
But he blunders along
And sings his low song,
As he sips the nectar fine.

FLYING-MACHINES AND AIR-SHIPS

AIR-SHIPS

BY DAY ALLEN WILLEY

WE use the word "air-ship" for the various designs of mechanism by which a man can move through the air; but strange as it may seem, the term cannot be found in all the dictionaries, so recently has it been coined. And in any case it is a word that seems misleading; for the name "ship" is associated with something that has sails. The air-ship, as we know it, is usually a bag containing gas or hot air, which is driven in various directions by an engine and steered like a boat, with a rudder. It is useless without its gas-bag, and cannot be kept in the air merely by its machinery. Really the aeroplane can more correctly be called an air-ship, because it has wings or sails against which the air-currents press and thus aid, not only in holding it above the ground, but in giving it motion.

If we call the aeroplane an air-ship, it is not a new idea by any means; for as far back as the year 1879 an ingenious man, Victor Tatin, a French scientist, made one which went through the air at the speed of twenty-five feet a second, or over a quarter of a mile a minute. As those were the times when the modern gas-engine, such as we use in the automobile and "power-boat," was unknown, compressed air was the motive force. It passed from an air-chamber into two propellers which forced the aeroplane through the atmosphere as a boat goes through the water. This air-ship, which made its successful flight at Meudon, near Paris, had two "wings" of light silk stretched on wooden frames which kept them distended. These wings or sails could be turned in different directions like the sails of a yacht, only, instead of being arranged up and down or in a vertical direction, they were nearly horizontal.

It is worth while to describe Tatin's air-ship because nearly all which have since been tried have been modeled with sails or wings. Of course, each type is different from its fellows, but usually in the number and shape of the sails. No man has invented a type which is without them, but the inventor has wrought such wonders with the engine that a motor has recently been built in Europe which actually has a power equal to the strength of a hundred horses. The ordinary steam-engine of this force would weigh so much that it could not be used for even the automobile, saying nothing of air navigation; but this European model is so very compact and light that two men can easily carry it on their shoulders. This is because it requires no heavy cylinders or boiler, which would be needed if it was operated by steam. No, its energy all comes from the explosion of gas. It has little tanks or cylinders into each of which a tiny spray of gasolene or some other inflammable oil is thrown, mixed with air. This vapor is fired by sparks from an electric battery. As it explodes it generates a gas so powerful that a little of it has as much strength as a much larger volume of steam—a strength that sends the motor-car whizzing along the highway at the speed of an express-train, and the power-boat rushing through the water at the rate of twenty to thirty miles an hour.

Yes, the vapor-engine, or whatever you choose to call it, has done more to make the real air-ship a practical device than anything else; but until recently, only the craft which had the gas-bag was capable of going into the air and making a journey of more than a few miles, in spite of the hundreds of kinds of wings and engines that have been fashioned. A few of those who would navigate the air as the sailor navigates the sea, have tried both the wings and the gas-bag. Santos-Dumont, the young Brazilian who made himself famous by what is termed the "dirigible

balloon," has experimented with the "flying-machine" or aeroplane as well, but the greatest distance he has ever gone is only a few feet compared with his balloon flights. One of the first, if not the first, successful aeroplane to be built in the United States was that with which the Wrights "flew" about a mile above the bleak sand beach of Cape Hatteras, North Carolina. The two brothers, who lived in the city of Dayton, Ohio, became convinced that they could construct wings so that they could fly like a bird. Going to this out-of-the-way corner of North Carolina to keep the rest of the world from knowing of their experiments, they made several gliding-machines, as they called them—boxes of light canvas held in shape by wooden sticks. These were open at the sides and not unlike the box-kites which are so much in use nowadays. Fastening a box upon his shoulders, one of the brothers would make a running start on the crest of a sand-hill and leap from the top with the wind facing him. This plan was so successful that one of the Wrights made a flight of 300 feet before he again touched the ground. The trials, however, led them to give up the idea of flying like a bird without some other force than air-pressure, so they designed several little engines for their aeroplanes, and with the aid of one of these they traveled a distance of over a mile without touching the earth, and "flew" as high as sixty feet above it.

The Wrights have designed types of aeroplanes for use in France as well as the United States. The American design was accepted by the United States government for military purposes after it had made an aerial voyage lasting over an hour, and at an elevation at times of 250 feet above the earth. In September, 1908, Orville Wright performed this successful feat with Lieutenant Frank P. Lahm, the aerial expert, as a passenger. This aeroplane, which was the most practical design which had yet been built in America, was forty feet in length. Its weight without passengers was 850 pounds, including a gasolene motor having the power of forty horses, which drove it through the air at the rate of thirty-nine miles an hour—the speed of a fast railway train.

Besides the box-kite there is the old-fashioned design still used by the boys fond of kite-flying. This is the kind where two sticks are fastened in the form of a letter X and a crosspiece attached, the upper opening of the X being smaller than the lower. That great scientific kite-maker, Alexander Bell, has changed this form into what he calls the tetrahedral kite, which will easily lift a man into the air, so much strength has it. Taking Professor Bell's idea, the late Professor Langley, of the Smithsonian Institution at Washington, designed a flying-machine with three or four wings made up of kite-cells of the tetrahedral form. This made a flight over the Potomac River but fell into the water and was ruined.

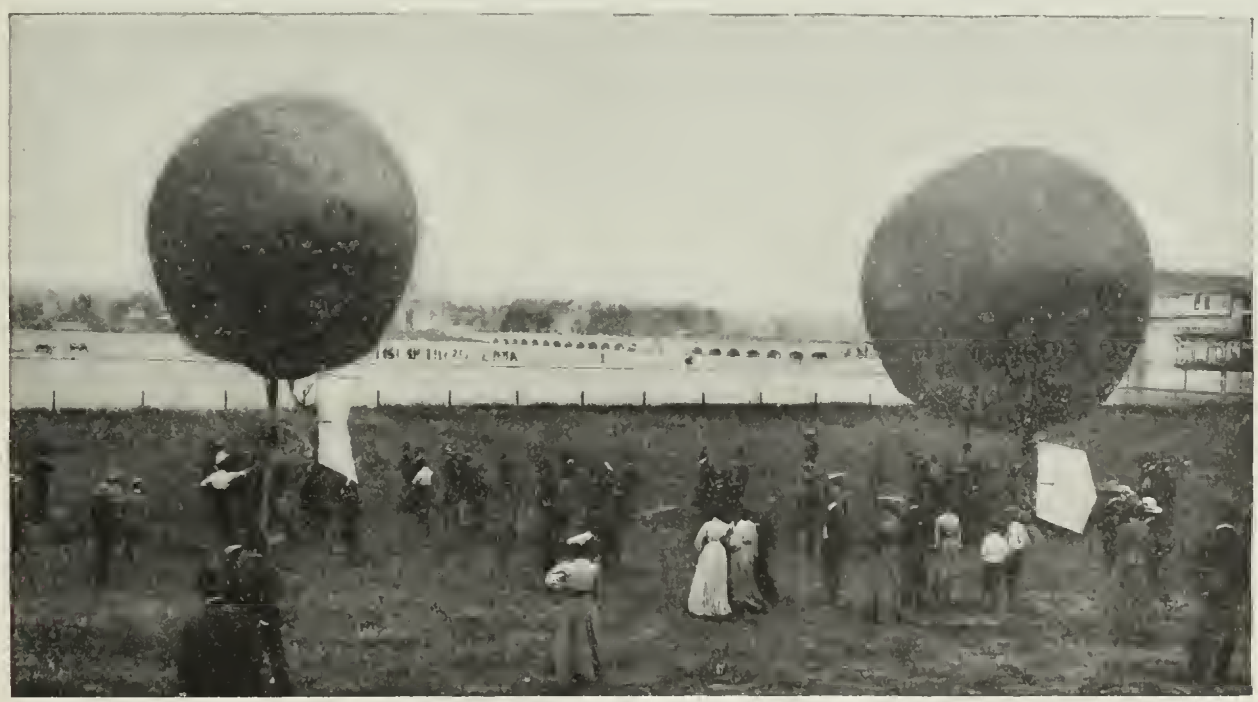
Copyright, 1908, by Underwood & Underwood, N. Y.

BALDWIN'S DIRIGIBLE (OR "STEERABLE") AIR-SHIP.

STEERING AN AIR-SHIP UPWARD BY SHIFTING THE MAN'S WEIGHT ALONG THE CAR-FRAME.

It was not long before many other inventors tried to excel the achievement of Santos-Dumont, but for a considerable while no machine was made that would remain in the air more than a short time. Of the great developments that later came we shall tell you in a separate chapter following this.

A simple explanation of "dirigible" is contained in the word "steerable." The dirigible balloon, which is what most people mean when they say air-ship, is simply a balloon which can be directed—its movements guided and controlled so that it travels in the direction desired by the aeronaut or navigator. It is just as much of a balloon as those which rose above the earth in the days when the great bags were driven here and there before the air-currents, and a man who chanced to be in the "basket" or perhaps hanging on the trapeze-bar had no control over them except to open the gas-valve and lower himself by allowing the contents of the bag to escape. The shape of the bag, however, has been greatly altered. It is usually in the form of a huge cylinder, narrowing gradually to a blunt point at each end, the greatest thickness of the cylinder being over the machinery. The reason why the bag of



TWO AIR-SHIPS STARTING FOR A RACE.

the modern balloon is shaped like a cigar or banana is because it offers less resistance to the air when moving in a horizontal direction. Sometimes three or four smaller bags are attached to the rear end or what the seaman would call the stern. The great French bag called "La Patrie" was of this pattern, as it was believed that the smaller bags aided to steady the larger one when in motion, and permitted the steersman to guide it more accurately with the rudder.

Running this sort of an air-ship is very much like running an automobile, except that the navigator must keep his craft far enough aloft as well as headed in the right direction; but by moving enough weight beneath the back part of the bag he can throw the front end at an upward incline and thus ascend as he goes forward. If he wants to descend he can reverse the position of the weight or release some of the gas by opening the valve in the bag. Should he wish to ascend vertically, he can do like the old-time aeronaut—throw over the sand-bags. The engine depends on the size of the balloon, which is usually large enough to hold it in the air with the passengers, even should it break down or stop from some other cause. It may be of five or ten or more horse-power, but it is always sufficiently powerful to whirl the big wooden, canvas, or aluminium blades of the propeller which, fastened underneath the rear of the bag, does the same duty in the air that the screw of the ocean liner does far beneath the surface of the sea. With its assistance the air-ship may travel at a

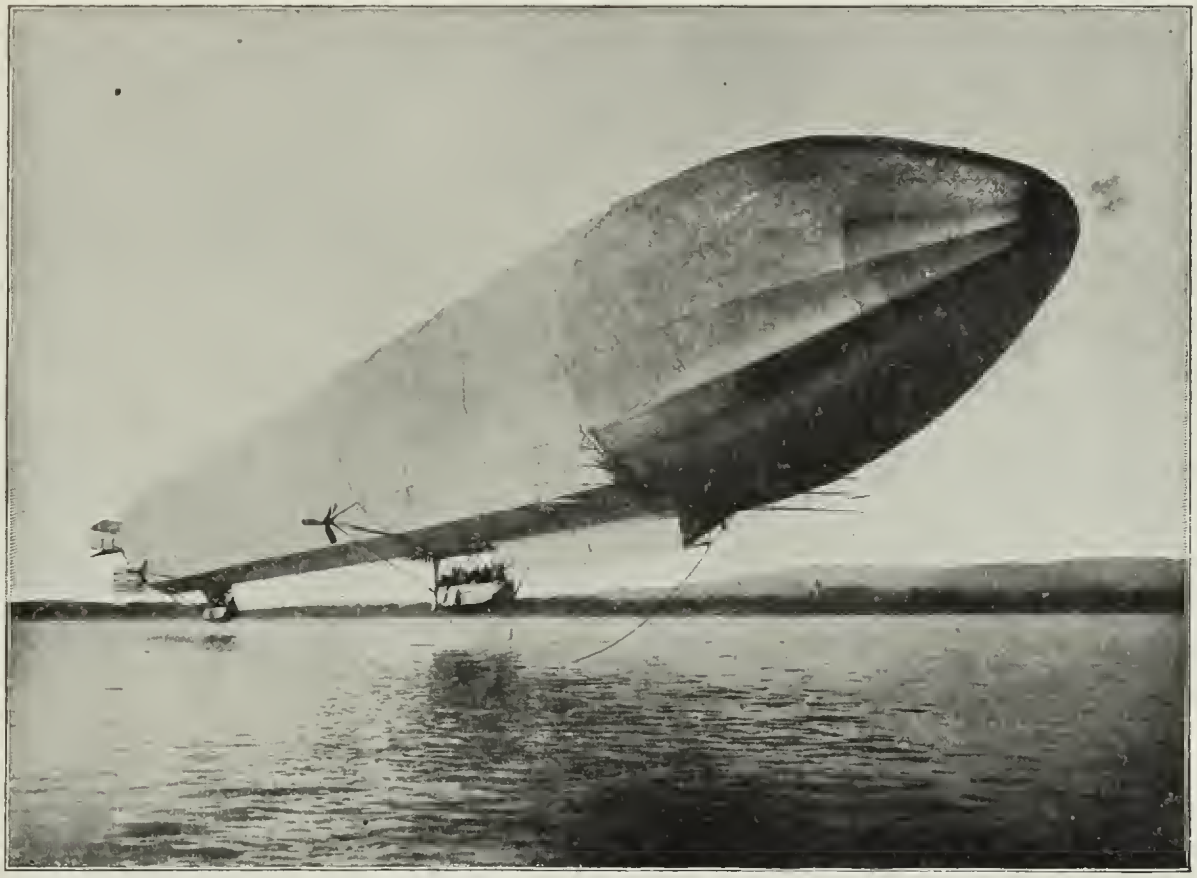
Photograph by Underwood & Underwood, N. Y.

THE TRIAL ASCENT OF THE AIR-SHIP "DIRIGIBLE II" IN ENGLAND.

Below the gas-bag, however, are many different contrivances. Of course there is the engine, possibly two or three, if the air-craft is very large. The basket in which aeronauts of former days usually ascended is replaced by a car which may be partly inclosed in glass as a protection from the weather. A narrow platform extending beneath the center of the bag allows the navigator to reach his engine and his ballast-bags hanging in rows in the rigging, and from this platform he may move the huge rudder by means of the ropes or wires which extend from it to the platform.

rate of twenty miles an hour or more, even against the wind.

The most successful dirigible balloon was probably the "Zeppelin," so called from its inventor. It was by far the greatest air-ship, if it may be termed such, yet constructed, while it had a record for attaining the greatest speed and lifting the heaviest load yet borne aloft. Count Zeppelin is a German officer who has spent several years in studying the problem of air navigation. His air-ship, which was built on the shore of Lake Constance, Switzerland, was about 420 feet long and was driven by two engines having the combined power of no less than 170 horses, while the great bag contained when filled 375,000 cubic feet of gas. This air-ship in its trials rose to a height of over 1000 feet above Lake Constance, carrying not only the machinery, but twelve passengers, and while in the air moved forward at a rate of over thirty miles an hour, the navigator turning it in circles and guiding it as easily as the motorist guides his touring-car on the ground. While this craft met with an accident and was destroyed shortly after its construction, another of the same model was completed which excelled its performances.



COUNT ZEPPELIN'S EARLIER AIR-SHIP, MORE THAN 400 FEET LONG.
Photographed in flight by E. Frankl, Berlin.

Several of the European countries have designed dirigible balloons to be used for military purposes. The one designed in England is called "Nulli Secundus," and after being completed made a trip from Farnsborough, where it was constructed, to the city of London, circling around several towers in the city and finally returning to its starting-point. "La Patrie," the French air-craft, also made several journeys of the same length guided without difficulty, but, unfortunately, broke from its fastenings and was carried out to sea some time ago. The United States has several types of war balloons and has recently asked inventors to plan air-ships which can be used for military purposes. American genius, however, has been successful in building models which are as practical as any of the European types.

A recent writer, looking forward to the future making and using of flying-machines, observes that there will no doubt be many improvements in them, once men have agreed that aeroplanes are the best means of sailing in the air. The machines, he says, will no doubt be made smaller than they have been, and all sorts of things will be done to enable them to carry as many passengers as possible, and to come easily to rest at stations. And even while this writer was saying these things, great progress was being made in the directions that he pointed out.

HOW A BALLOON IS SENT UP
SHOWN BY A SET OF PHOTOGRAPHS "TAKEN ON THE SPOT."

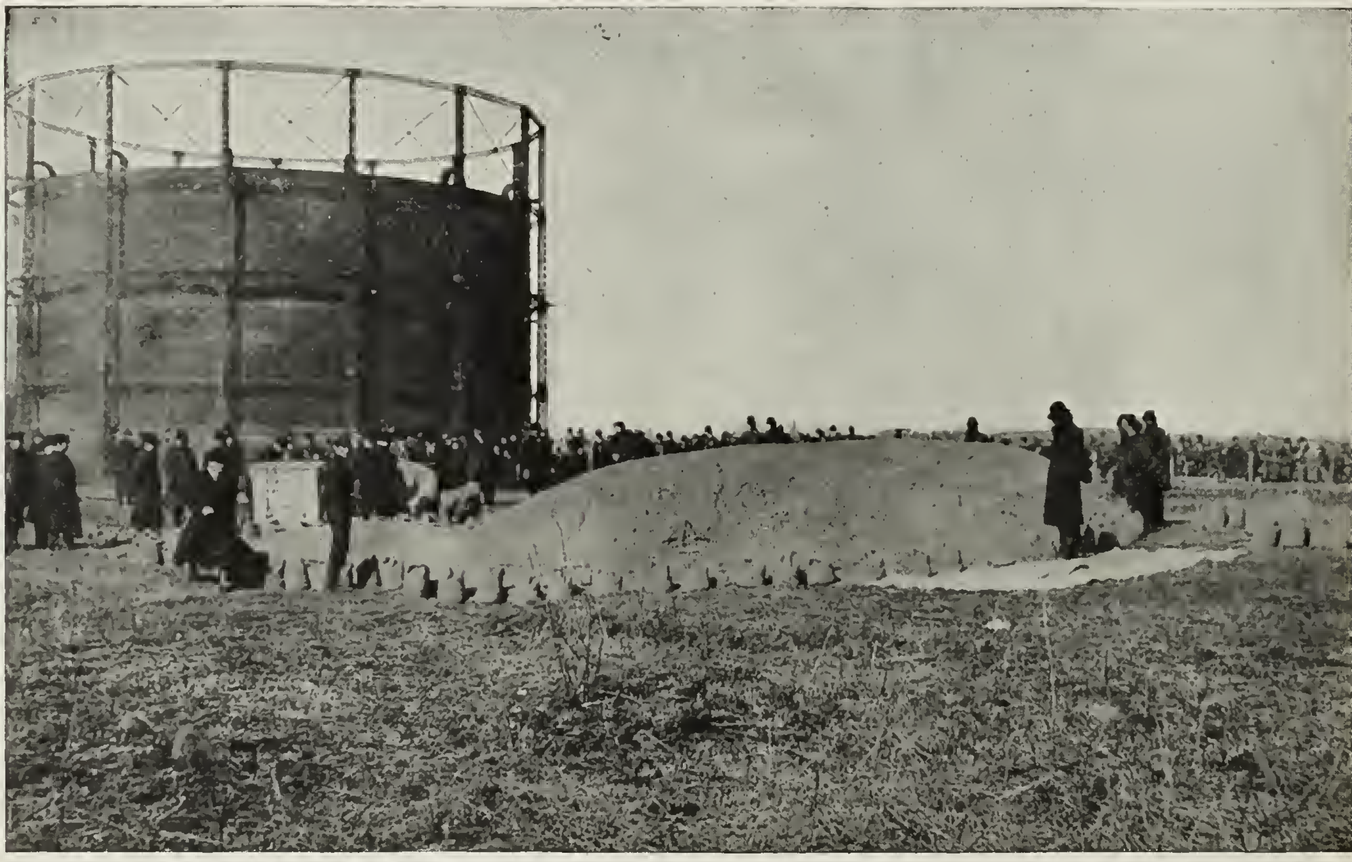
UNROLLING THE BAG OF THE GREAT BALLOON.

STRETCHING THE FABRIC OUTWARD FROM THE VALVE-HOLE IN THE CENTER.

WALKING ON THE BALLOON TO GET TO THE VALVE-HOLE. THE AERONAUT CAREFULLY LAYS A STRIP BEFORE HIM TO PROTECT THE FABRIC FROM BEING TORN OR INJURED BY HIS SHOES.

SCREWING THE VALVE-RINGS TOGETHER ON THE FABRIC.

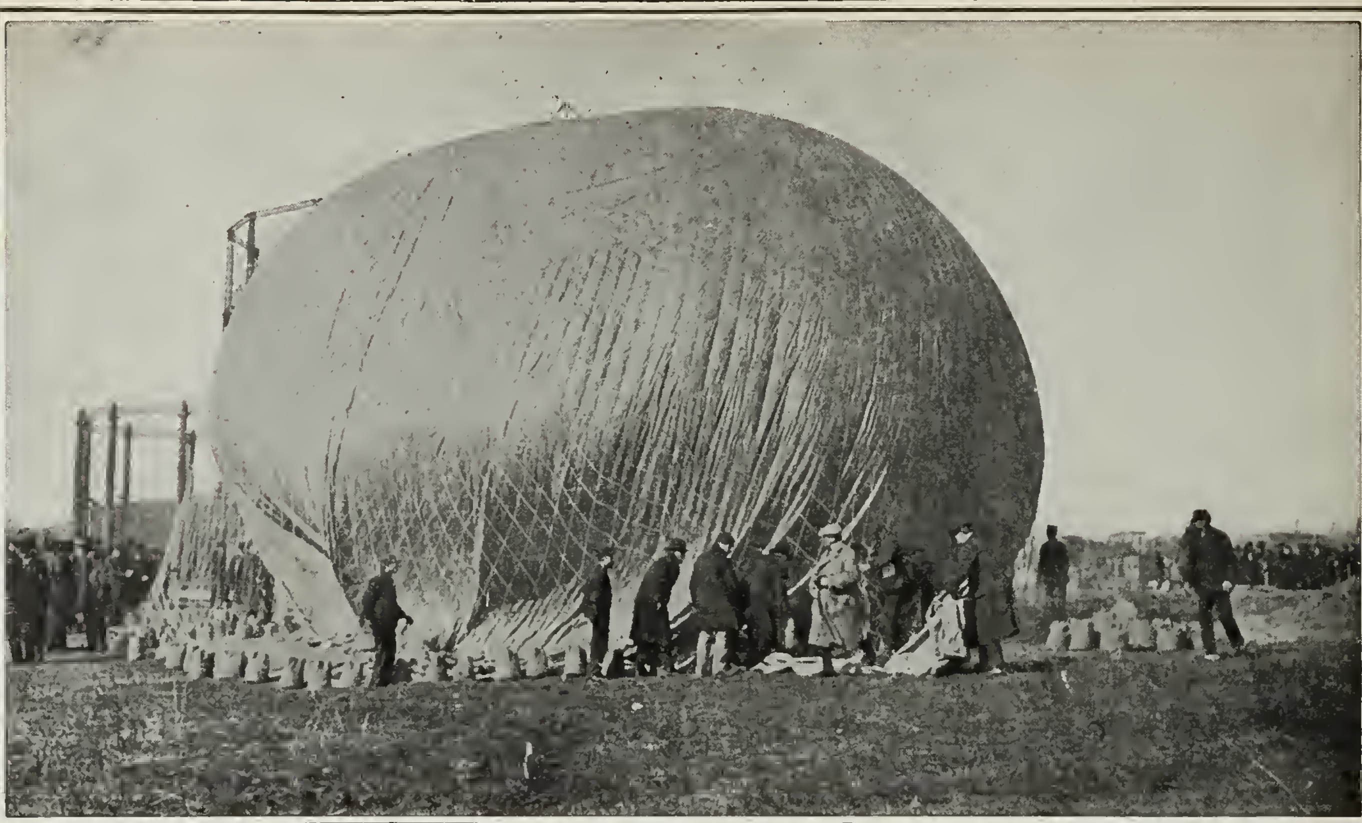
STRETCHING THE NETTING OVER THE BIG BAG. THE GAS TO FILL THE BALLOON IS TO BE FED FROM THE GAS-RESERVOIR NEAR BY.



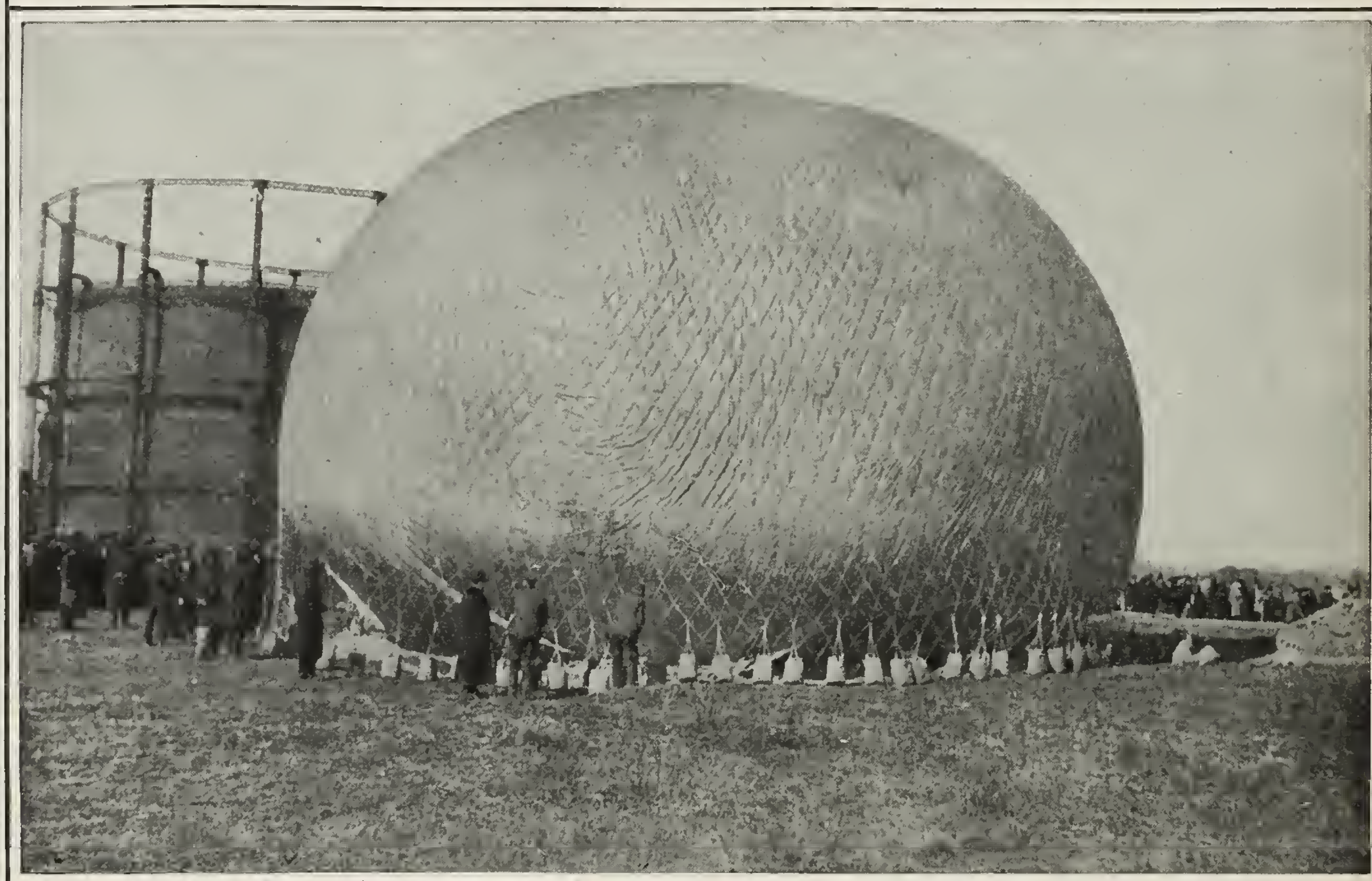
AS THE BALLOON BEGINS TO FILL, SAND-BAGS ARE PLACED ALL AROUND AT THE EDGE OF THE CORDAGE.

THE GAS IS FILLING THE BALLOON SLOWLY. THE VALVE IS SHOWN NEAR THE TOP.

AS THE BAG FILLS, MEN WALK AROUND THE BALLOON SHIFTING THE BAGS TO LOWER LOOPS OF THE CORDAGE.

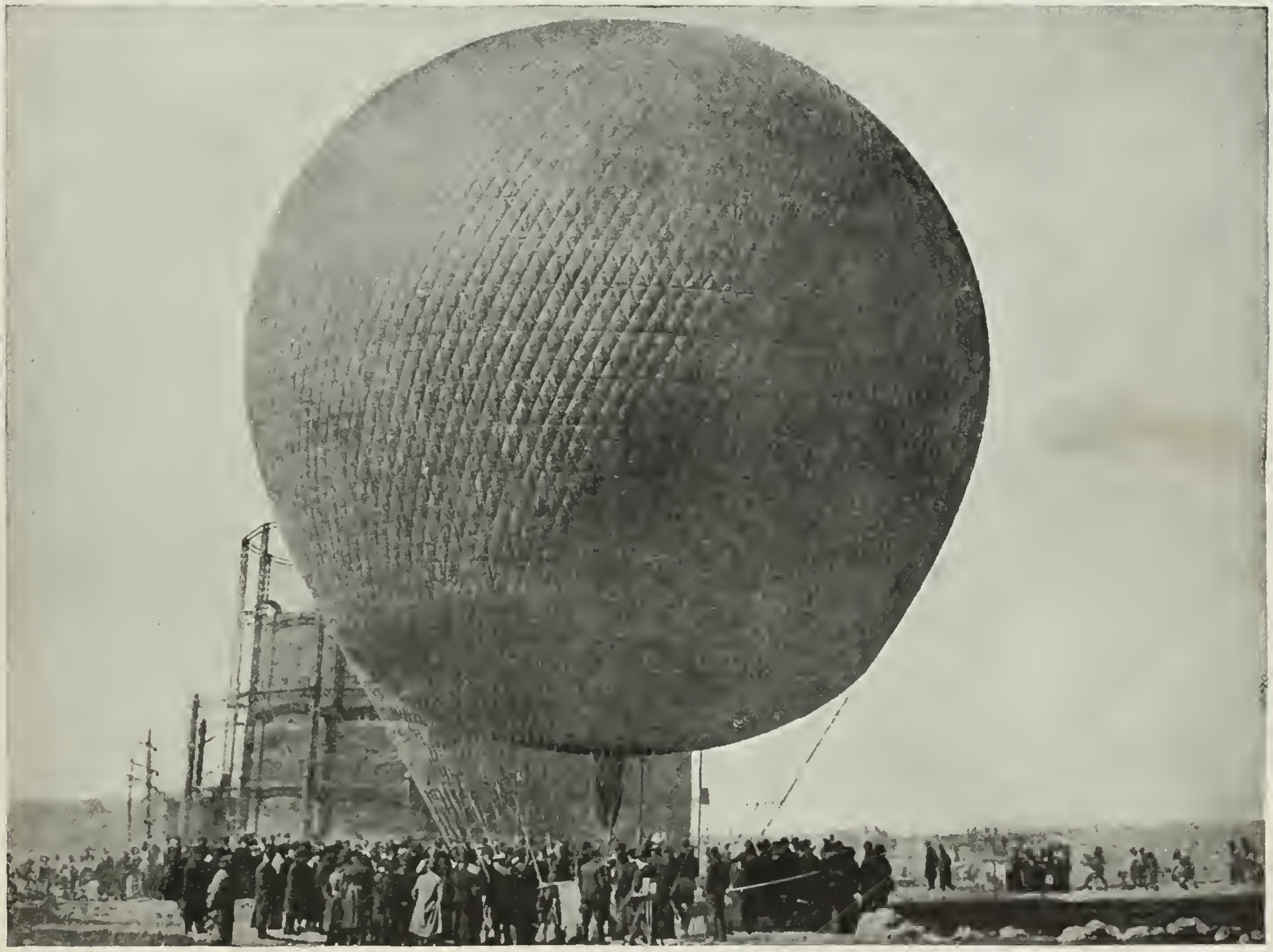


UNLESS THE CORDAGE IS KEPT TAUT BY THE SAND-BAGS ALL THE TIME THE BALLOON IS FILLING, THE SLACK ROPES WILL ALLOW IT TO BE BLOWN ABOUT BY THE WIND.



THE BALLOON AS HERE SHOWN, IS ABOUT HALF FILLED.

IT BEGINS TO LOOK LIKE A BALLOON—WILL BE FILLED IN HALF AN HOUR.



THE MEN PULL IN THE CORDAGE AT THE BOTTOM, PREPARING TO ATTACH THE BASKET.

STILL PULLING IN THE CORDAGE TO NARROW IT DOWN TO THE BASKET. THIS PICTURE GIVES A GOOD VIEW OF THE FILLING-PIPE OF THE BALLOON THROUGH WHICH THE GAS IS POURING INTO IT.

WHEN THE BALLOON IS FULL OF GAS, THE SAND-BAGS ARE SHIFTED TO THE LEADERS AND PULLED IN TO THE BASKET SHOWN IN THE CENTER.

ALL ABOARD, AND OFF!

STILL GOING UP—UP—UP!

A FEW MINUTES LATER.

COMING DOWN.

ALMOST DOWN!

"HERE SHE COMES!"

ABOUT FLYING-MACHINES

BY TUDOR JENKS

How quickly the art of flying became a reality! We all knew that the scientific men were trying experiments, and we all hoped that we might live long enough to see flying a reality; and then one day came the news that "two brothers out West" had really made a long flight in a machine of their own invention. The news was doubted at first, but the reports were so quickly verified that doubt gave place to an eager curiosity to know what the new machines were like. When we saw pictures of the new flying-machine, it proved not so very different from a well-known type; but in the small difference was the reason for success—for the machine *was* a success, and showed men how they might at last gain dominion over the air. And so, in the year 1903, the long seeking for a flying-machine led to the first that was built on true principles.

Now let us see how the conquest of the air was won.

That men have always wished to fly we may know from their giving wings to all superior beings; angelic messengers, fairies, demons, witches receive the power of flight as a matter of course. And, wishing to fly, it was certain that men would at first study the habits of birds, and would argue as Darius Green did:

> "What 's the use of wings to a bumblebee
> Fur to git a livin' with, more 'n to me—
> Ain't my business
> Important 's his'n is?"

Certainly it looks easy, when one sees the "swallows skim along the smooth lake's level brim"; and for a long, long time men thought that if they had wings like the dove, of course larger and stronger, they could at least make a beginning. So many tried the experiment. It was not hard to build a pair of wings "of leather or of something or other," or even two pairs; and many kinds were made—so many that the most ingenious of boys with the best sort of tool-box probably could not invent a new variety even if he worked all summer.

Some of these early wing-makers lived in the shadowy days of history. Bladud, a British king, was one; but all that we learn of his flight is that he soared above his city of Trinovante, and then fell upon a temple, thereby ending his wings and himself. Bladud belonged to an unlucky family, being the father of Shakespeare's "King Lear." Simon, called "the magician," who lived about the time of the Emperor Nero, lost his life in the same way; another martyr to the science was a monk called Elmer (or Oliver) of Malmesbury, who had foretold the invasion of William the Conqueror, and was therefore taunted by cruel people when he did not know beforehand that he would break his legs on taking flight from a tall tower. This monk is said to have flown 125 paces. People laughed at him all the more when he said that he failed because he did not fix a tail to his feet; but a recent writer, Chanute, argues that the monk was very likely right in his conclusion.

A hundred years later, and more, a Saracen repeated the attempt, and, like poor Oliver, was killed. Then we read of a relative of the poet Dante, who made a successful flight over a lake, and fell in trying to repeat the feat across a square in the city of Perugia—though even upon this second attempt he is said to have "balanced himself a long time in the air," and to have fallen only when his wings broke.

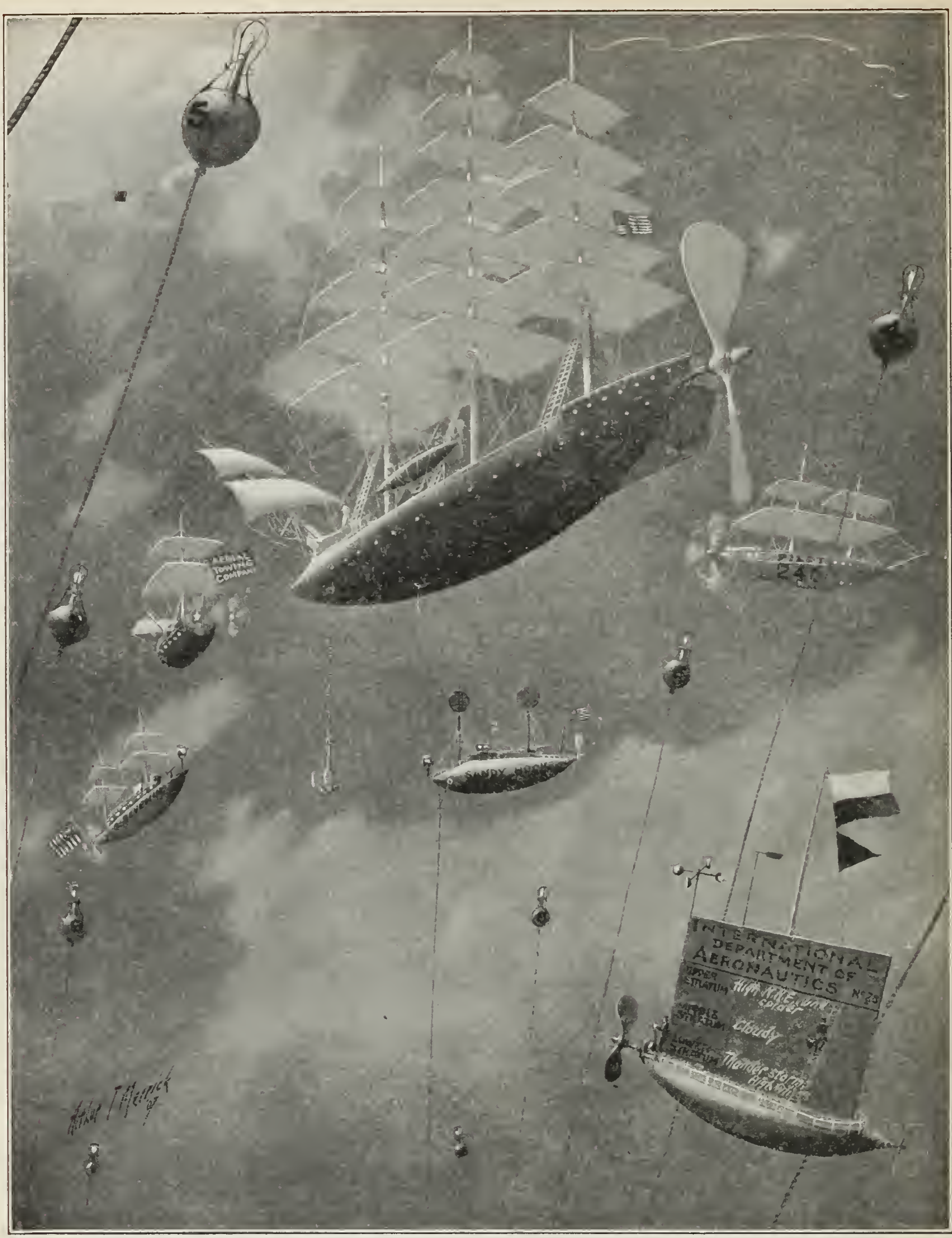
We do not know what wings these men had, but from later facts it seems likely that the stories told of them are true. We know nowadays that with stiff wings men can often sail long distances, and such flights as are reported seem to have been made with fixed wings and from high places.

After men became more skilled in the making of machinery, they tried to make moving wings; but it was found that the moving wings would not raise men from the ground.

Leonardo da Vinci, being a great architect and engineer, as well as painter and sculptor, left note-books proving that he had studied the flight of birds, and had planned flying-machines to be driven by wings or by screw-propellers. But as Leonardo was good at figures, he seems to have abandoned his plans after finding out how much power would be needed.

A French locksmith thought that practice was the great thing; and, fitted with wings, he jumped first from a chair, and afterward from a window, and then from the roof of a small house. In the last experiment he sailed over a cottage roof, but soon after sold his wings to a peddler—and probably saved his own life. Another Frenchman, a marquis, tried to go by the air-route across the river Seine; but he was not drowned, since a washerwoman's boat happened to be where he came down.

From those early days until recently, inventors



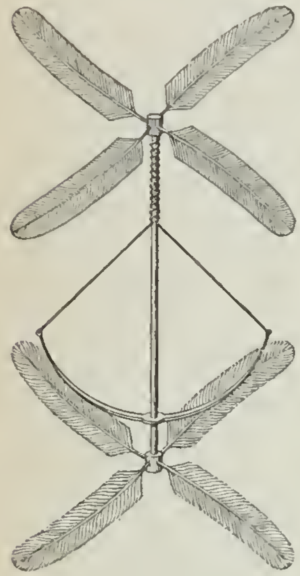
NEW YORK SKY HARBOR IN 1950.

UP THE MAIN AIR-SHIP CHANNEL.

A peep into the future through the eyes of Arthur T. Merrick, an artist.

kept on building large wings and small wings, driven in every sort of flapping, by legs and by arms; but it is useless to quote the long list of failures. They proved only this: A man is not strong enough to flap wings big enough to hold him up; and man's muscles move too slowly to flap wings as fast as a small bird can.

All well-instructed inventors of to-day know that in order to fly with flapping wings man must have some far greater power than his muscles. Many light motors have been tried in the form of models. The principal ones —explosive compounds, steam, electricity, springs, and rubber bands—have been reasonably successful when the models were small enough.


AN EARLY MODEL.

The subject of flying models is interesting, but it will be possible here to describe only a few that will serve to show the different kinds used before successful aeroplanes.

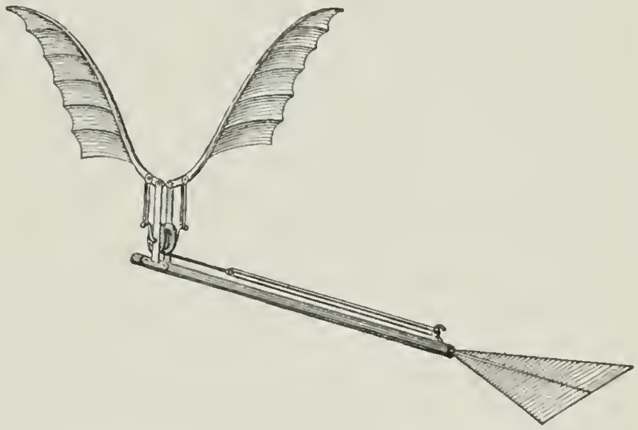
One of the earliest was made by putting four feathers into a cork so as to make a propeller. Two of these propellers with feathers sloping in opposite ways were set on a stick, one propeller being fixed, the other revolving. A bow of whalebone was attached so that its cord could be twisted around the stick. Upon winding up the cord, and then letting it go, the model would be driven upward.

A drawing will make this clearer. The whalebone-bow is pierced to let a wire through, and works easily on it. The rod is jointed at the bow, and the upper propeller turns from right to left, the lower in the other direction; but the feathers are so sloped that both sets tend to move upward. This model is described because it is not hard to make, and will fly pretty well. To make the upper rod movable, that part may be a hollow stick put on a wire fixed into the lower part.

A simpler model on the same principle is the one known as Pénaud's "Hélicoptère," or, in English, "screw-wing," the invention of a clever young Frenchman who made some of the best models, though he worked only a short time on the subject, and died when he was thirty.

It is the simplest form of the flying-screw, and is moved by a twisted rubber band. It is wound up by turning the lower wings, or propeller, and when released flies in the same way as the one in the picture. A common Japanese toy sometimes found in toy-shops illustrates this principle. It is an imitation butterfly that will fly as high as the roof of an ordinary house.

These two forms will show how the screw-models work. Those driven by flapping wings may be more briefly described, for they do not fly so well and are harder to make. The least complicated ones were made by Jobert and Pénaud. In Jobert's a stretched rubber band pulls a cord and revolves a pulley. The pulley turns two little cranks that move the wings up and down. Pénaud's model works on a similar plan. In both the wings are stiffened by a rod along the front edge, while the rear edges are flexible; so the wing slides forward on the air as it descends.

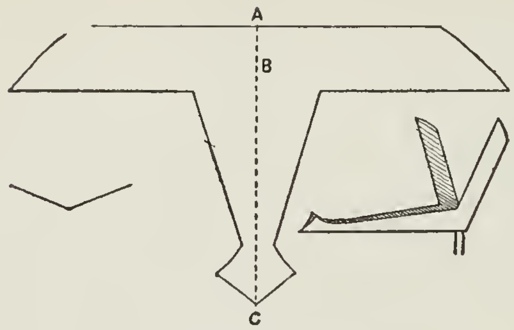

JOBERT'S MODEL.


PÉNAUD'S MODEL.

A third sort of model shows the aeroplane method of flight, that led to success in making real flying-machines. This new method uses flat or curved surfaces, sliding quickly upon the air, to support the weight. Scale a card through the air, and it travels upon the air, holding itself up so long as it has momentum.

In order to see just how aeroplanes act, take a piece of writing-paper, about eight inches long

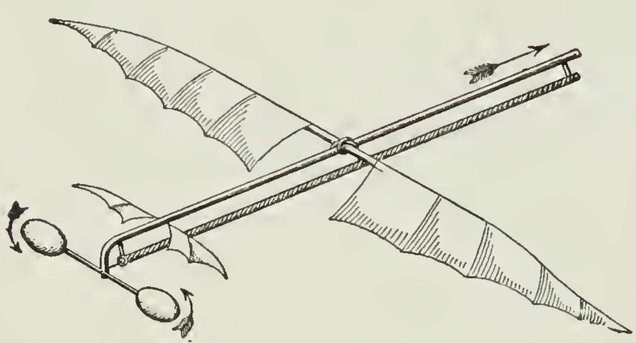
and four inches wide, and cut from it a paper bird like this:



PAPER AEROPLANE.

Then bend it along the line AC into a flat V, putting two pins at B, as near the head as you conveniently can. Now stand on a chair and drop the bird, and it will come down as if it were a hawk after a chick. The weight of the pins pulls it down, the wings resist by pressure against the air, and the paper bird *slides* down instead of falling direct.

When the wings are sloped a little upward at the forward edge, and the planes are pushed forward by a propeller, they rise on the air. To illustrate how aeroplanes may be caused to rise, here is an early model made by the Pénaud already mentioned:



PÉNAUD'S AEROPLANE MODEL.

The little wings at the rear are set at a greater angle than the large wings; and whenever the front begins to droop, they resist more, and thus bring the head upward again. They do this the more easily because the front wings lose some power whenever they are nearer level.

A simple diagram will show how these rudder-wings act.

The model is made heaviest at the head, C. If it begins to go downward, as at 2, the rudder-wings at A come more directly against the wind and pull back, raising the head; the wings B, meanwhile, are edgewise to the air, and offer little resistance, so the model goes faster. When the model rises, as at 3, the rudder-wings are flat, and stop lifting, while the wings at B push against the air, and slow down the flight until the weighted head comes level again.

The result is that this model flies in a wavy line, up and down, like a sparrow.

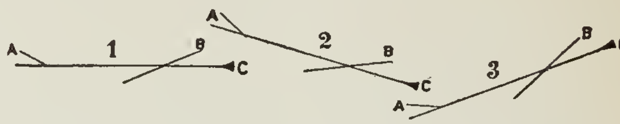


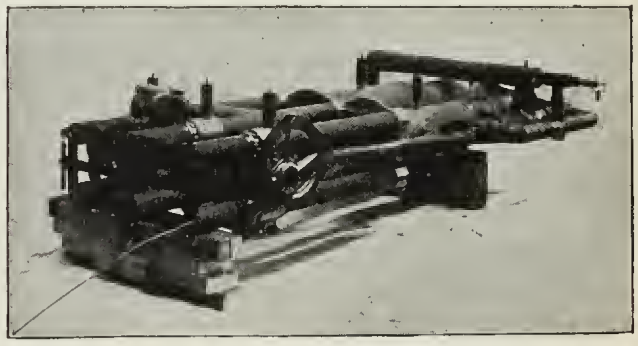
DIAGRAM SHOWING ACTION OF RUDDER-WINGS.

This aeroplane contained valuable hints for future inventors; and modern inventors used the same method to control the earlier flying-machines.

Many of the little models fly excellently; but to make the machines big enough to carry men, new difficulties have been overcome. Big machines cannot be driven by twisted rubber bands, or, if they could, the flight would be no safer than if the machines were fired out of cannons, like the projectile in which Jules Verne's heroes made their imaginary "Trip from the Earth to the Moon." And when any machine fell, it would be smashed to smithereens—together with its passengers. A toy may be allowed to fly into the air, and then fall to the ground; but a flying-machine must not only rise, but must keep right side up while on its voyage, and must then descend safely.

Consequently the prudent air-ship maker must in all cases provide, first, enough power to carry his ship aloft and drive it where he chooses, in anything short of a hurricane; second, a method of balancing securely while aloft; third, a method of coming down in safety.

Of all means for lifting and driving the air-ships—balloons, wings, screw-propellers, and aeroplanes—it has been decided that the planes are the best supports, and by their use was the problem solved.



ONE OF MAXIM'S STEAM-ENGINES.

And this decision was no piece of guesswork. Careful experiments were made, especially by two Americans—Samuel P. Langley and Hiram Maxim—both learned men, and both well in-

WHAT YOU MAY SEE ON SOME FINE DAY IN THE FUTURE.

formed about all that had been done before our own times with all sorts of flying-devices, to determine just what form of aeroplanes was best worth trying. Their experiments were made separately.

There was a number from which to choose, for men had tried to fly with planes as with every other apparatus. A model aeroplane was made that flew fairly well, and the design was patented in 1842 by Henson; but he never made a large machine.

Du Temple made trial of a similar plan, but all known engines were too heavy for it—even though this inventor and his brother seem to be the first who made their boiler of light tubes, as is the present method with steam-engines. In 1875 an English enthusiast named Moy built a large air-ship driven by screws and held up by planes. It was run around a circular track, being fastened by a rope to a pillar, but did not make speed enough to rise from the ground. Lack of power, which came partly from lack of money, perhaps, kept Moy from making an air-voyage.

Only a word or two more can be spared to these inventors, clever as many were. Each added some useful fact to what was known before him. Thus Wenham, in 1866, showed that planes could usefully be put over one another; Brown, in 1873, that planes at the two ends of a rod would balance well; then came Moy, already spoken of, and Tatin, who made a model that flew in a circular track, which Moy's machine failed to do. In 1879 Dandrieux, a Frenchman, made a model much like the Japanese toy already spoken of—a paper butterfly driven by twisted rubber. A similar model with undulating wings was made by Brearey, who added an elastic cord extending from the under side of one wing to that of the other. This made the down pressure stronger, and gave better flight.

These machines, and many others, made the task easier for inventors who came afterward, by showing which experiments promised the best

results; and their experiences gave Maxim courage to make his flying-machine on a large scale.

Langley and Maxim began as modern men of science do—each made trials of all sorts to find what material and what shape would give best results; and Maxim built and tried every kind of motor that suited his purpose. He tried engines moved by hot air, oil, steam, or electricity; and at last convinced himself that the steam-engine was the easiest to manage, and gave nearly as much power for its weight as any motor. The gas-engines were not perfected till later.

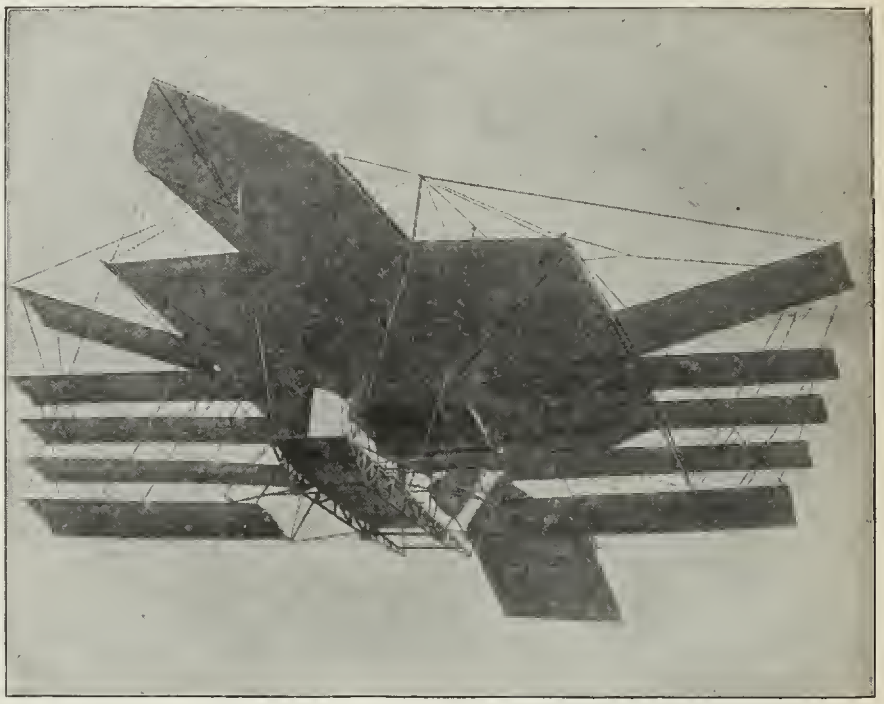
While Professor Langley made less outward show than Mr. Maxim, perhaps it will be found that his experiments and writing did as much for the art.

Scientific men thought that if an engine could be made weighing less than forty pounds for each horse-power, flying-machines could lift it and themselves by its aid. Now, by using light tubes to make his boiler (the same plan is adopted in torpedo-boats), Maxim constructed the two lightest engines then built. Weighing only 640 pounds together, they gave 360 horse-power—much more than was thought necessary for flying. For their weight these engines were nearly five times as powerful as those Moy had tried, though Moy's were considered a marvel of lightness and power in 1875. The rapid advance in modern science is shown by this improvement in less than twenty years.

The engine being ready, Maxim tested different fabrics until he had found out the best material for making the aeroplanes—his bird's-wings. The tests were made on an ingenious little machine that showed how much each piece of stuff would lift, and how hard it tried to go with the current of air blown against it.

He found that an aeroplane made of a special kind of cloth called "balloon fabric" would, with the same weight and power, carry more than any balloon could lift.

Then Maxim went to work on a large air-ship to be driven by screws and supported by planes. The body of the machine was a platform car on wheels. The car, forty feet long and eight feet wide, carried the two little engines. Above were the aeroplanes of cloth, stretched by wires upon a framework, the largest being fifty by forty feet, and capable alone of lifting most of the weight. It was meant also to make the machine fall slowly, for it would act as a parachute in falling. At the sides were smaller planes, and in front and behind were planes movable up and down—rudders to steer upward or downward.



MAXIM'S AEROPLANE OF 1893, AS IT WOULD APPEAR IN THE AIR.

The machine ran along its own railroad, a track a third of a mile long, and could be driven by the push of its air-screws as fast as most locomotives.

The inventor soon found that when the car ran at a high speed it tried to rise from the track; so he built guard-rails above to keep his flying-machine down. You see that Maxim did not intend to go up until he had made sure of keeping his balance and coming safely down.

The air-ship and its appliances were finished in 1893, the engine being so arranged as to use naphtha for fuel, and to condense its own steam into water, so that it could be used over and over.

All these matters required time, labor, and money—to say nothing of the brain-work—and over $50,000 was spent before the air-ship began its trips along the rails.

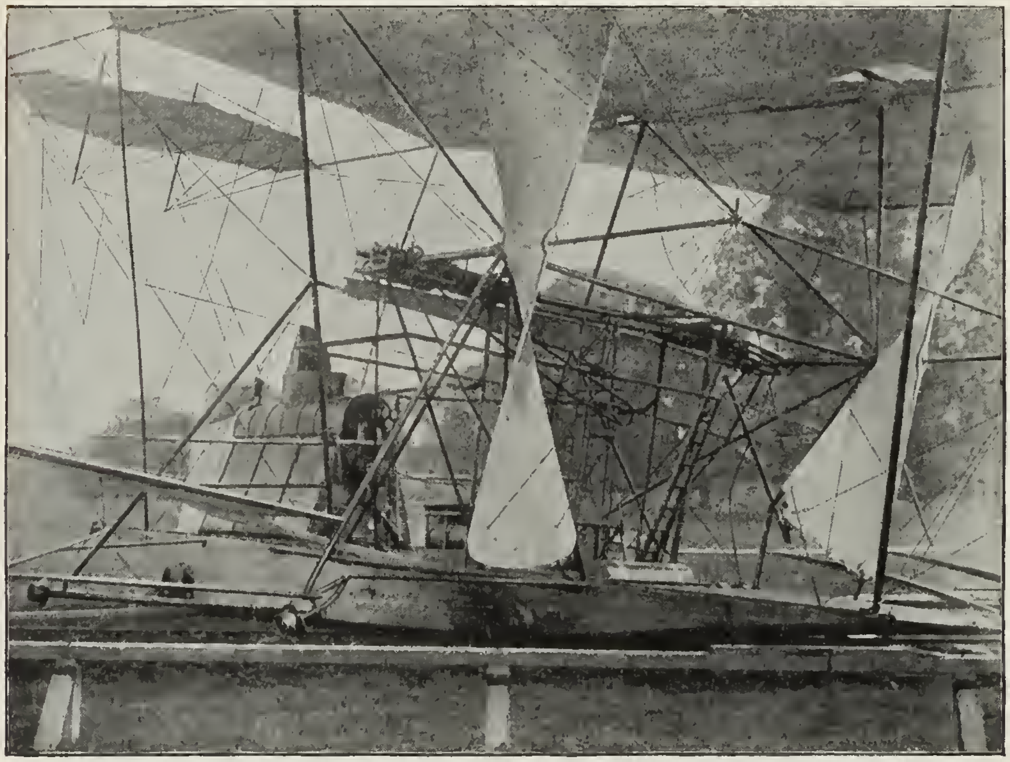
Then the inventor began his lessons in flying, taking careful notes of the machine's behavior at different rates of speed. It was soon proved that when three quarters of the power was used, three of the car-wheels left the lower track, and at full speed the whole machine ran on the upper track, free from the ground. It was also found that the side-planes would keep the air-ship from rolling over, and that the action of the fore and aft rudders promised to be satisfactory.

When the whole machine was in the best of

By permission, from "Ueber Land und Meer."

WARFARE IN THE AIR, AS IMAGINED BY A GERMAN ARTIST.

order, it was run at a speed of thirty-seven miles an hour. The planes lifted all four wheels and the machine ran upon the *upper* track for some distance. But the lifting-power was too great. An axletree of one of the rear upper wheels was bent—the air-ship was set free and the front wheels broke the guard-rail. Steam was shut off and the ship dropped.



VIEW OF THE PORT SIDE OF THE MACHINE AFTER THE ACCIDENT.
Showing the axletree which, by bending, led to the accident.

The broken rail did some damage; but the ship was repaired, and Maxim at all events had made a very helpful experiment.

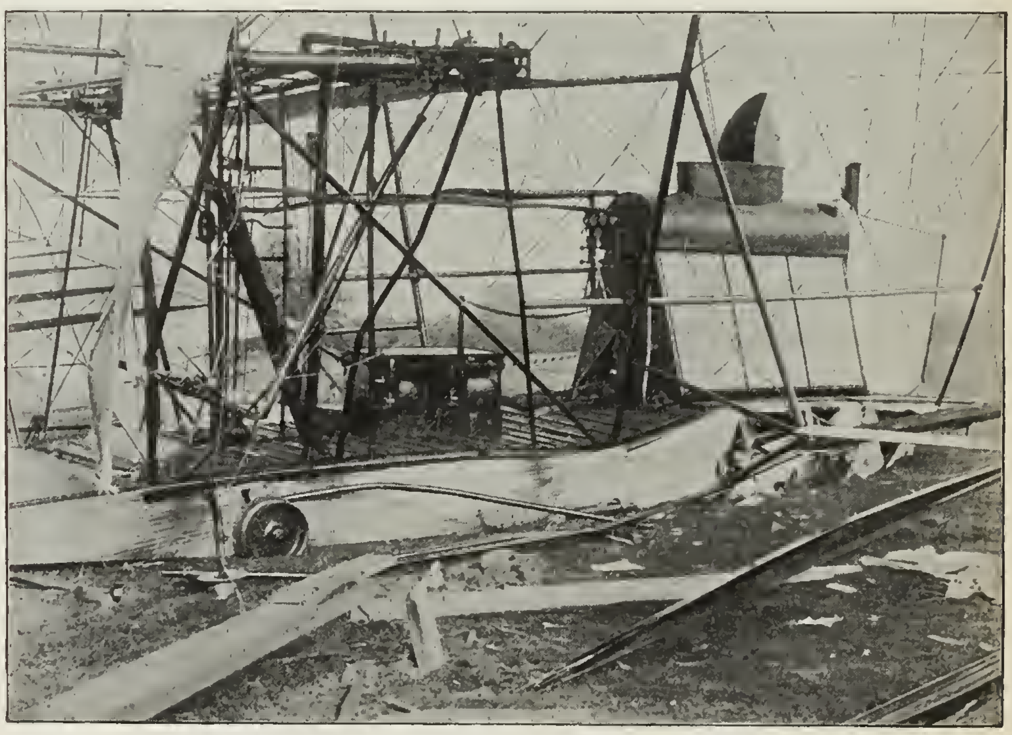
Here is Mr. Maxim's opinion upon the result:

Had it been known twenty years ago that a machine could be made on the aeroplane system which would really lift its own weight, its fuel, and its engineer, we should have had plenty of flying-machines in the world to-day. If one half the money, time, and the talent which has been employed by the French balloon corps in their fruitless efforts to construct a navigable balloon should now be employed in the right direction, the whole question of aerial navigation would soon be so perfected that flying-machines would be as common as torpedo-boats and the whole system of modern warfare would be completely changed.

So much for the aeroplane up to the year 1893. Meanwhile another sort of flight has been attempted, and to some extent successfully, by other inventors. This is the soaring or sailing flight. You may see it in operation almost anywhere if you will keep an eye upon the gulls, hawks, eagles, and other soaring birds. Yet it was long doubted whether any bird could sail in the air with motionless wings. Nowadays the evidence that such flight is not only possible but usual is overwhelming.

Maxim believed, and it is now known, that birds are aided in this soaring by the many minor currents in the air, of which the bird takes full advantage.

Chanute, in his book "Progress in Flying-Machines," shrewdly remarked that stories about men flying successfully have come almost entirely from the warm countries—the regions where steady winds make soaring birds a common sight. His book told nearly all the experiments in flying in which men depended on their own strength.



THE STARBOARD SIDE AFTER THE ACCIDENT.

Among the most striking instances of flying are the experiments made many years ago by a Frenchman named Le Bris.

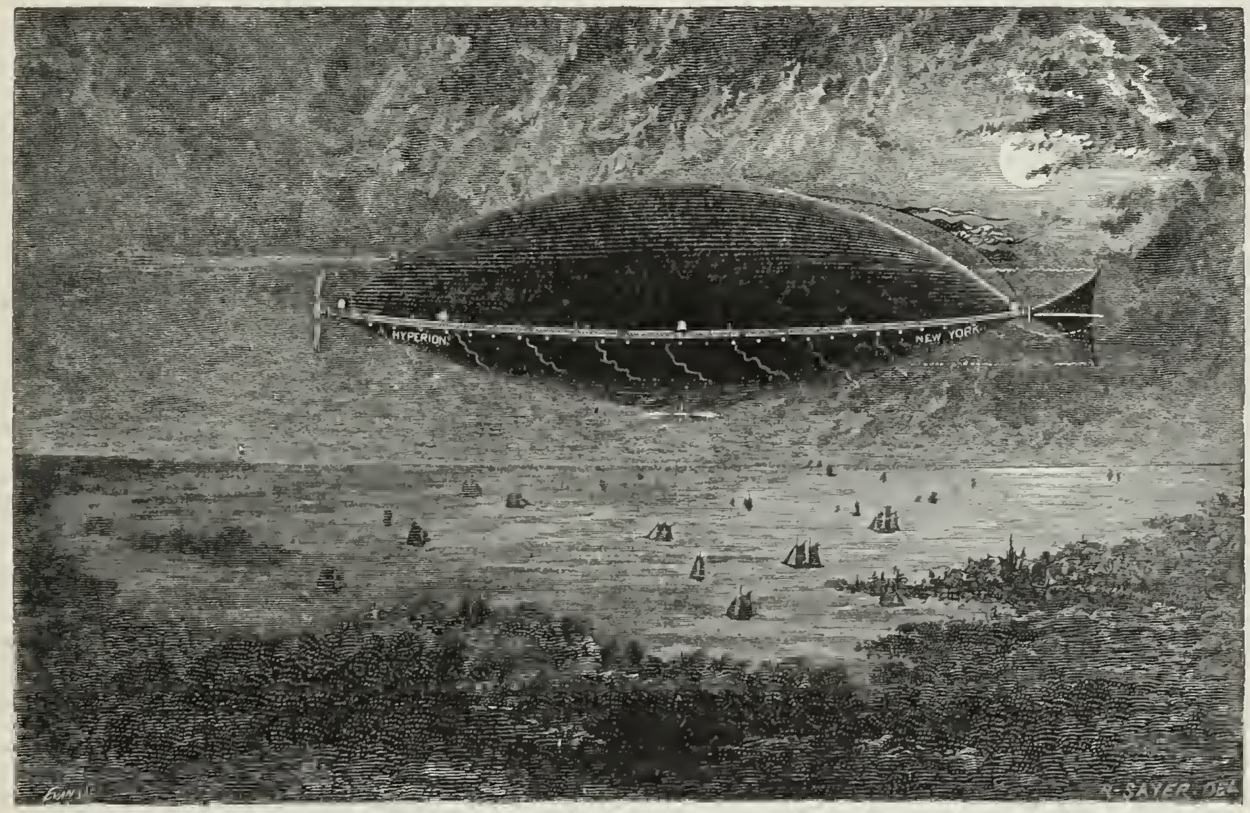
Le Bris once held up in the breeze a wing he had taken from an albatross, and, he says, "in spite of me it drew forward into the wind." He wondered if he could make wings that would act in the same way, and about 1855 he built a bird-like boat with outstretched wings that could be moved slightly by rods. Then he placed the machine upon a cart, got into it, and told the driver to drive against the wind. When they started Le Bris kept the front edges of the wings bent downward; but soon the horse began to trot, Le Bris raised the front of the wings, and behold! up went the boat until (so he said) it was higher than the church steeples, and floating along *against the wind.*

But soon Le Bris heard energetic remarks in the air below him, and found that the driver had been caught in the rope and was then dangling down like the tail to a kite. So Le Bris turned the wings so as to glide downward until the driver was on solid ground, and could run after the runaway horse and cart.

Le Bris tried to return to the upper air, but failed; and he came down unhurt, having only slightly injured the machine.

The air-boat being repaired, Le Bris soon made another start; but this time he had Humpty Dumpty's luck and the machine was smashed to bits. With a second air-ship he once went up forty feet, and he flew the same vessel loaded with ballast even higher. When this second air-ship was smashed, Le Bris gave up, for he was a poor man and could not afford another.

These flights were *against* the wind, and proved that surfaces curved in a certain way were drawn forward "into the wind's eye," as sailors express it. This fact was explained in a book written in 1864, and its author, D'Esterno, was laughed at and considered out of his head because he claimed that flight was possible with a machine built to soar rather than fly—that is, without power to drive it, and with motionless rather than with flapping wings.

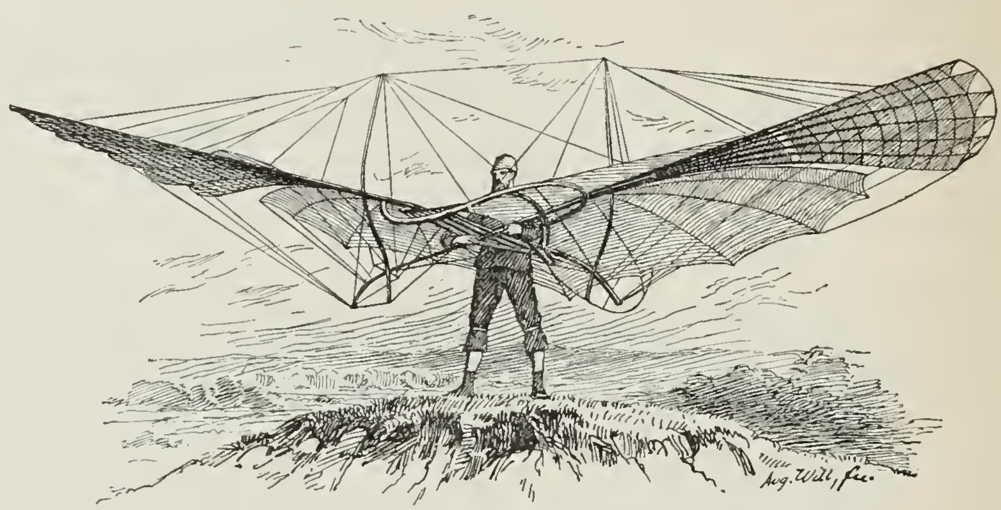


AN IMAGINARY AIR-SHIP OF THE BALLOON TYPE.

The same belief was urged in "L'Empire de l'Air" by Mouillard, a book on the flight of birds. Mouillard claimed that, after a start, a bird can rise without motion of the wings provided the wind is strong enough. The author built such wings, and tried them by leaping at a narrow ditch. Up he went, and then glided 138 feet before he came down and broke a wing. A second trial was successful also, except that in coming down he sprained his shoulder.

And still later a number of "human birds" repeated and varied these trials. Although great feats have not yet been done, it looks as if the chief trouble is lack of practice. One of the best known and most skilful fliers was a German named Lilienthal, who, after years of study and

trials, made in the summer of 1891 a pair of wings curved like a great bird's. As the result of his studies and experiments, he believed curved surfaces better than flat planes—in which he "agreed with Le Bris, Goupil, and Phillips, other students of the subject. All these men believed that the curved shape of birds' wings has much to do with their flying, helping them to go against the wind—a strange effect which the French have named "aspiration." To-day this has been established by many proofs.

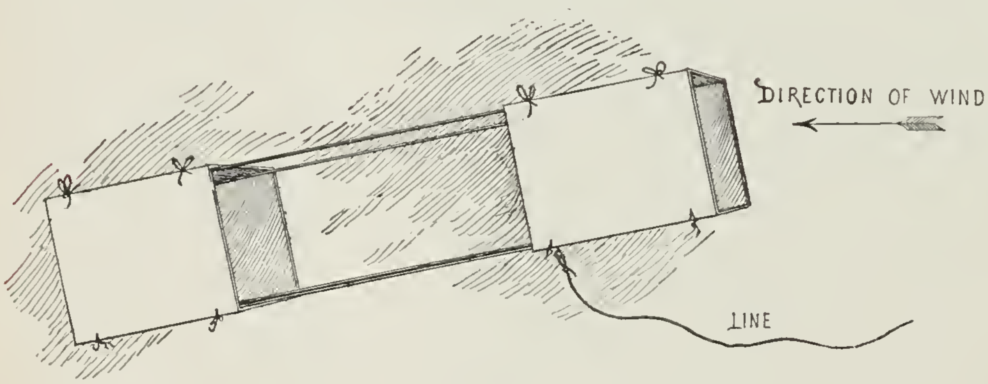


OTTO LILIENTHAL ABOUT TO TAKE FLIGHT IN HIS GLIDER.

Provided, then, with wings and tail, Lilienthal began to practise, at first upon a spring-board, and afterward in a hilly region near Berlin. Even after he was able to sail as far as eighty feet, he found that it was best to arrange the wings so that they could be easily thrown off; otherwise, he coolly says, "I might have had a broken neck instead of sprains which always healed in a few weeks."

In 1892 he made larger wings, and learned to sail farther than before, rising twenty or thirty feet from the ground upon a favoring wind. But in 1896, during one of his bold feats of soaring, Lilienthal lost control of his apparatus and was killed—a martyr to the science of flying, and a helper toward success.

Some Americans also during this period were at work with wings, among them A. M. Herring of New York, who was said by a paper to be "experimenting with wing-surfaces large enough to carry his own weight for over a year!" Herring succeeded in sailing *300 feet*.



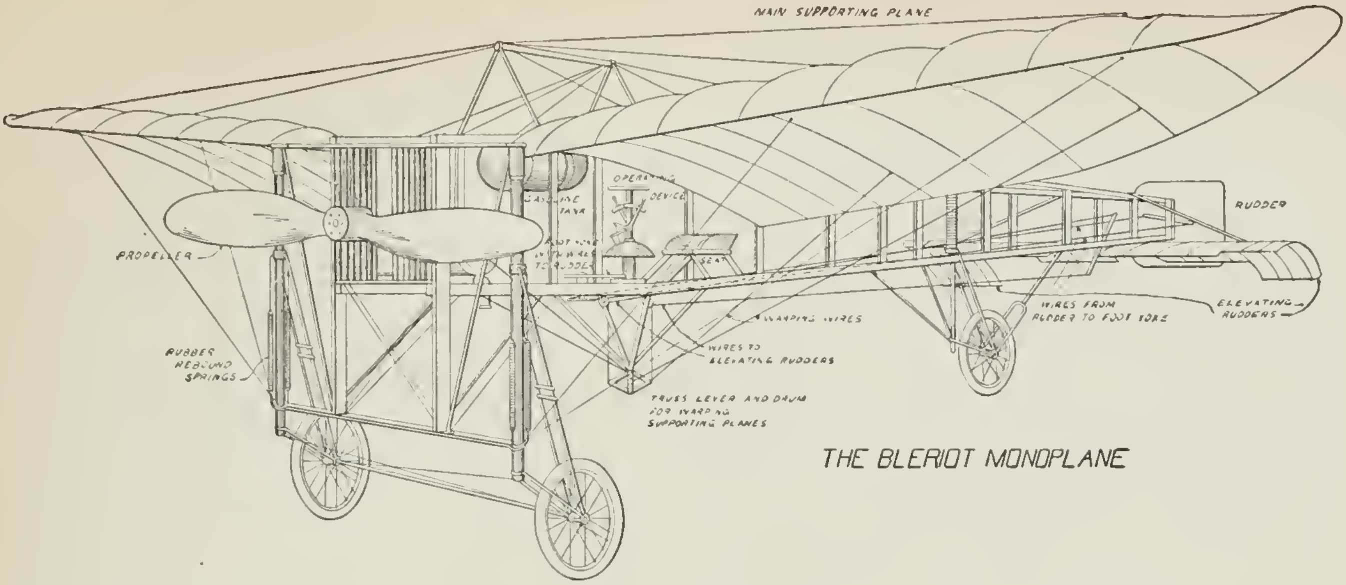
A KITE ON HARGRAVE'S PRINCIPLE.

In 1895 Mr. Pilcher, of Glasgow, made flights with wings not unlike Lilienthal's; but to guard against being upset by sudden gusts—a constant danger—Pilcher bent his wing-tips at the ends. These experiments contain a hint of the device that the Wright brothers afterward used.

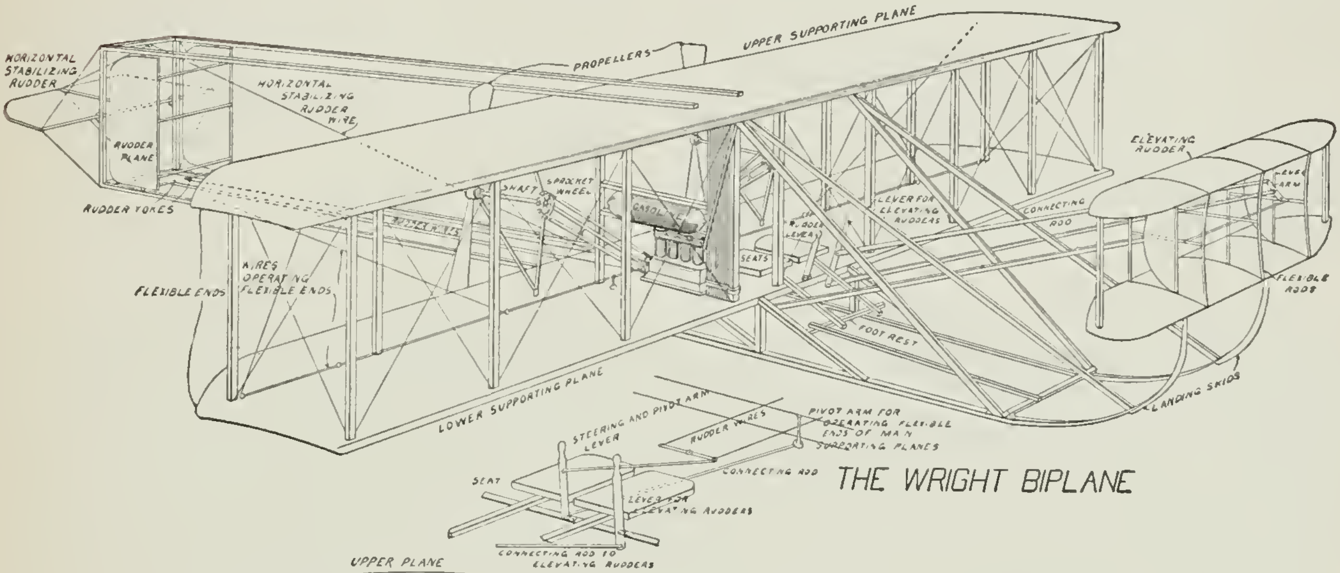
There were other experimenters at work, on different lines, in various parts of the world, but none yet more successful. Lawrence Hargrave of New South Wales made a great number of simple and successful models—one being driven by compressed air, and flying over 300 feet. He next gave his attention to kites; and in November, 1894, made one that carried him up along a string, and brought him safely down. Meanwhile other experimenters carried on the work, among them Wilbur and Orville Wright, of Dayton, Ohio, who discovered many valuable principles. They used a flat plane in front for steering up or down, and invented a safe means of balancing by bending the ends of the main aeroplane surfaces as found necessary—a true Yankee invention, and one that gave the flier control of the machine.

By 1905, using a gas-engine, they made many successful flights—one of nearly twenty-five miles, which was covered in half an hour. The problem was solved, the flying-machine was a reality, and thenceforward the rapid advance of improvement becomes bewildering.

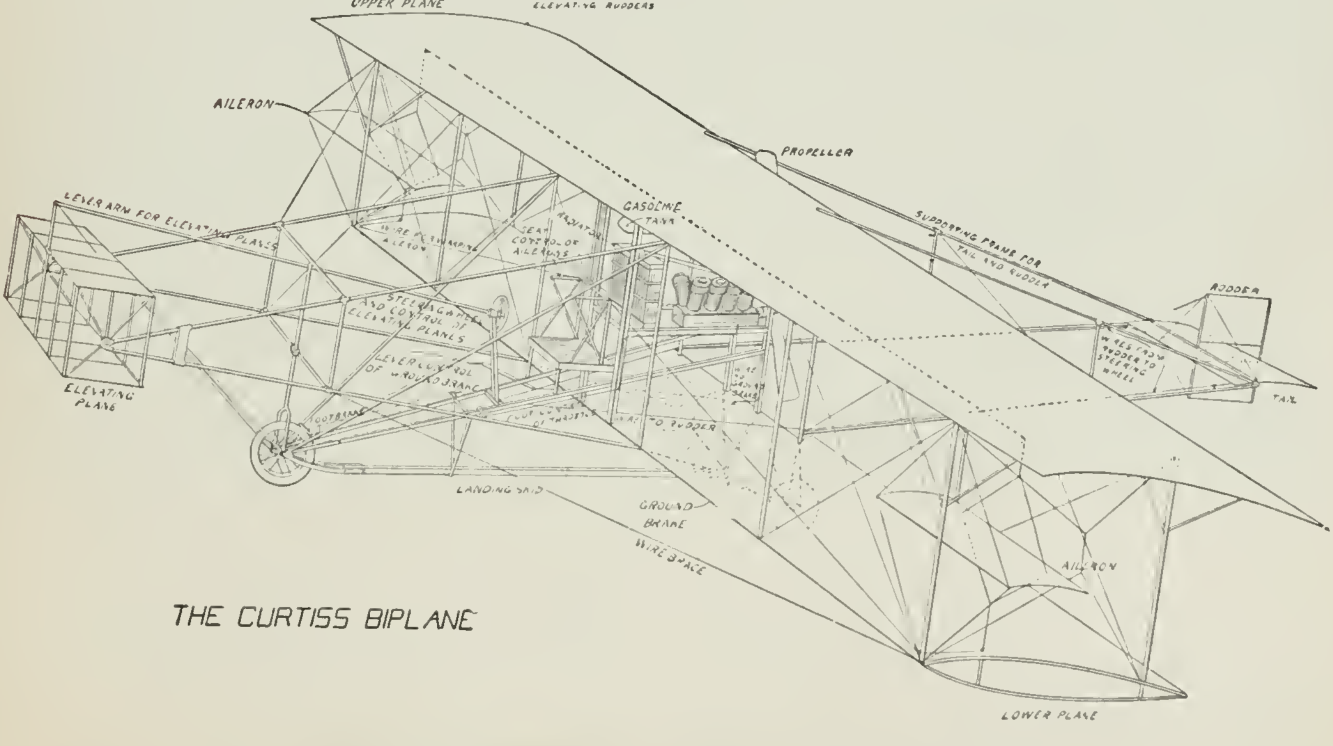
Aeroplanes of all shapes and plans became possible by reason of the invention of the gasolene-engine. Santos-Dumont, Henry Farman, Delagrange, and especially the Wright brothers, made many long flights, remaining in the air longer and longer, and learning the management of their machines. By December of 1908 Wilbur Wright made a flight lasting over two hours.



THE BLERIOT MONOPLANE



THE WRIGHT BIPLANE



THE CURTISS BIPLANE

THREE TYPES OF SUCCESSFUL FLYING-MACHINES.

But, now, before going on with the history of the flying-machine, let us see what its invention was expected to accomplish.

"The air will be the ocean; or, rather, let us say, that ethereal ocean, the atmosphere, at last having been utilized and made available for the commerce, the travel, the swift running to and fro of men, every spot of this globe will be a building-site, every acre a harbor, every open space, plain, hummock, the highest range, the humblest valley, an aerial port. . . .

"The change will be gradual. The art of aerial navigation will be slow of perfection. Our primitive vessels and motors will be rude and defective, as Stephenson's locomotive now would seem to us. Heavy freights must long continue to move by water and rail. Aerobats at first will be used for the transmission of the mails and light express packages, and especially for their swift conveyance over sea. Soon the inland companies will have each its own 'aerial express.' By and by aerobats displaying the insignia and pennons of the great newspapers will leave town at 3 A.M., and whir over the country 'as the crow flies,' and at their utmost speed, dropping their packages in the towns and villages along the routes in every direction of the compass. Soon the more adventurous and resolute, and finally all classes of travelers, will avail themselves of the great passenger aerobats and enjoy the unsurpassable luxury of flight, experiencing thrills of wonder and ecstasy, and a sense of power, freedom, and safety to which all former delights of travel may well seem tame by comparison. . . .

"In every way the resources of social life will be so enlarged that at last it truly may be said, 'Existence is itself a joy.' Sports and recreations will be strangely multiplied. Rich and poor alike will make of travel an every-day delight, the former in their private aeronons, the latter in large and multiform structures, corresponding in use to the excursion-boats of our rivers and harbors, the 'floating palaces' of the people, and far more numerous and splendid. The ends of the earth, its rarest places, will be visited by all. The sportsman can change at pleasure from the woods and waters of the North, the run-ways of the deer, the haunts of the salmon, to the pursuit of the tiger in the jungle or the emu in the Australian bush. An entirely new profession—that of airmanship—will be thoroughly organized, employing a countless army of trained officers and 'airmen.' The adventurous and well-to-do will have their pleasure-yachts of the air, and take hazardous and delightful cruises. Their vessels will differ from the cumbrous aerobats intended for freight and emigrant business, will be christened with beautiful and suggestive names—Iris, Aurora, Hebe, Ganymede, Hermes, Ariel, and the like—and will vie with one another in grace, readiness, and speed."

So wrote the poet Edmund Clarence Stedman in an article for the "Century Magazine," as long ago as the year 1879. And to-day we see the beginnings of all that he so wisely prophesied.

In 1909 the French aviator Blériot crossed the English Channel, and Henry Farman stayed in the air more than four hours. By this time there were so many airmen that aviation meets were held in many large cities, at which successful flights were hourly exhibited. In 1910 long flights were taken, one being that of Paulhan from London to Manchester with but one stop. This won a prize of $50,000 and was a marvelous feat for its day, though now so far exceeded.

The flights of 1909 and 1910 were no longer the mere experiments of the previous years; the later fliers made actual journeys in the air without waiting for fine weather; they flew over the sea, or over fields and towns, and they carried not only small packages, but even a passenger or two, and they went at great speed, covering as much as 50 to 150 miles. Various feats were performed, such as going thousands of feet upward, and flying from the deck of a battle-ship to the shore. Of course there were some tragedies; but, considering the novelty of the feats and the number of ascents, these were not many—far fewer than have been met with in the use of the motor-car, for example. And that the aeroplane was considered likely to be of use in war is shown by the fact that the practical French had sixty of them in 1910.

But the rate of progress in 1911 cast that of the previous year into the shade. Feats once thought extraordinary were then hardly noted in the day's news. Exhibitions were held in nearly all civilized lands, and hundreds of schools taught the art of flying to all who cared to pay the fees. Papers and magazines gave place to the experiences of "birdmen," factories began to make aeroplanes and all the needed supplies for the new art, and thousands enjoyed the sensation of flying in some two hundred varied types of machines.

The newer things in the year's progress were the coming of the "hydroplane," a craft that would rise from the water into the air, and then descend to the surface on which it had floated; and the revival of the attempt to fly in a "glider," or aeroplane without a motor. This last feat, performed by one of the Wrights, resulted in a flight 225 feet high for over ten minutes in a gale blowing some 50 miles an hour.

Though thousands of flights might be men-

tioned, it will be enough to record the journey of the American Rodgers, who flew from New York to Los Angeles, over four thousand miles, in three days and ten hours of actual flight, going at the rate of over fifty miles an hour. Of course we are counting only the time *in air,* for he took many days on the way, being injured at one time, and compelled to rest for weeks. Early in 1912 Rodgers fell with his machine and was killed, as so many aviators have been, in this country and others—costly sacrifices to the advancement of aerial enterprise.

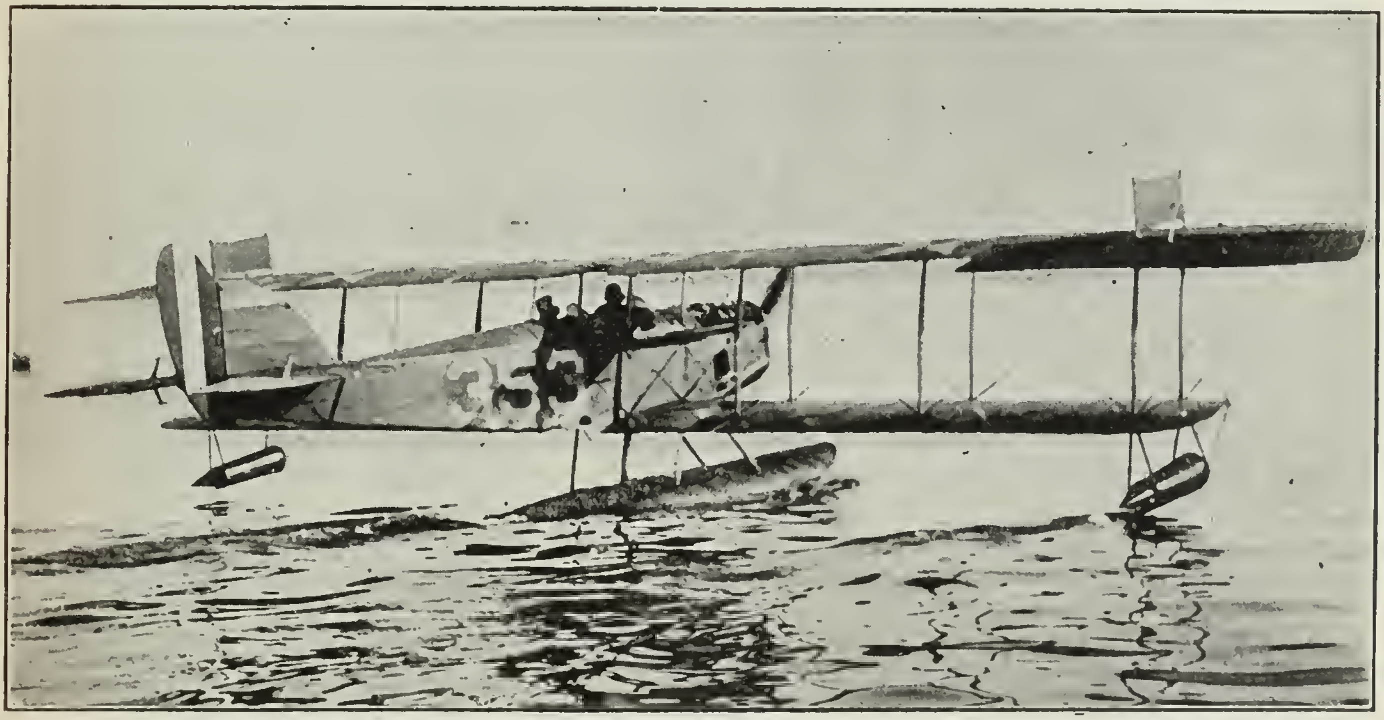
When the Great War broke out it was expected that the enormous balloons named for Count Zeppelin would prove to be the battleships of the air. They were used chiefly by the Germans for the bombardment of unfortified cities like London. They killed many helpless civilians, but were forced to fly at such heights that they produced trifling military damages.

The real fighters proved to be the light-winged aeroplanes. Three types were developed: The small craft used for reconnoitering; larger vessels employed for bombing fortresses and entrenchments; and large battle-craft used in mighty duels in the air. This new kind of warfare called for the most intrepid heroism, and brought forth on both sides notable instances of chivalry and daring.

While the war was progressing the aeroplane began to be used in the mail service, and the return of our military aviators is bound to bring tremendous progress in the development of air-ships for the use of passengers and commerce.

The air-ships are here, and we begin to see what they will mean to the world. They will make it possible to explore all parts of the earth; they will go anywhere without need for road-making; they will cross deserts, or fly over the loftiest mountain-peaks; they will carry mails faster than the quickest express-trains; they will afford a new sport; they will create a new sort of literature; they may make it nearly possible to stop smuggling; and it is hoped that they may put an end to war.

Whatever the future may bring, the world can never again be the same as before men learned to fly, and the young people of to-day will at least see a world that contains what King Solomon could not find—"something new under the sun."



Copyright by Committee on Public Information

A Hydroaeroplane at Rest

MARVELS OF EARTH AND OCEAN

I

By Mrs. Charles F. Hartt

Astronomers tell us that once upon a time the earth was melted throughout, as the sun perhaps is to-day; but in the lapse of ages the outside of it cooled down until a crust formed all over its surface. This is the "solid ground" on which we live, and we shall presently see that it is not so solid as it appears. Scientific men differ as to the exact thickness of this crust, but a majority believe that it cannot be greater in proportion to the diameter of the earth than the thickness of an egg-shell to the mass of an egg.

Now it is true that the depth reached by the deepest mines is but trifling in comparison with the thickness of this crust, yet it is sufficient to enable us to prove the law that the deeper we penetrate the earth the hotter it grows, and at the rate of about one degree for every ninety feet of descent. Artesian wells bored to a depth of two or three thousand feet always bring up warm water, and hot springs often appear to come from still greater depths.

It seems rather appalling, but, according to this reasoning, at a depth of about twenty miles the rocks must be red-hot, and, a little farther inside, everything must be melted; and this ocean of lava is the foundation on which rest the "everlasting hills," as we often call them.

It would take too long to tell you how the crust of the earth has risen and sunk on this molten sea—lifting its surface above the ocean to form land, and sinking away down under water; how it has crumpled up like the skin of a drying apple, only that the crumplings were hundreds or thousands of feet high and sometimes extended thousands of miles, forming mountain-chains. You will learn all this by and by, when you study geology. What you need to know now, in order to understand how volcanoes are formed, is the fact that this crust has cracked through from time to time with immense cracks, some of which have extended for hundreds of miles.

If lava were only melted rock, it might be thrown out with less noise, but it is full of intensely heated water and gases of various kinds tremendously compressed. Now it may be a new idea to some of my young readers, that water may be made extremely hot and yet not boil. If you put some water in a tea-kettle and set it on the stove, you must heat it up to 212 degrees Fahrenheit before it will boil, and it will not get any hotter, no matter how fierce you may make the fire beneath it.

If some water is put in a strong vessel corked tight, it will be found that the steam which is formed and cannot escape presses on the water, and it may be heated much above 212 degrees without boiling; but if the pressure be suddenly removed, the water flashes into steam, and there is a tremendous explosion.

When I was a child, I corked up some water, one day, in a stout vial, and set it on a stove. Wondering why it did not boil, and not knowing any better, I at last took out the stopper, when it exploded, driving out the contents of the bottle. I narrowly escaped a scalding.

The water had been too much heated, and of course as soon as the pressure was taken off, it flashed into steam. Precisely what happened to the water in the bottle, happens in a volcanic eruption. As the melted rock with the imprisoned water and gases comes up toward the surface of the earth, and the pressure grows less, it at last reaches a point where the water instantly changes into steam. Then, in the crevice in which this takes place, the steam and liberated gases blow out everything before them, straight up into the air with a puff of smoke and steam, and a noise to which a cannon is but a pop-gun. Great rocks are sometimes torn off from below and hurled miles into the air, and sometimes the lava, liquid as water and exceedingly brilliant, is spouted up like a fountain to a height of several thousand feet. The explosions are sometimes so terrible that tracts of land a mile square are blown bodily into the air. Of course when so great a quantity of loose stuff is thrown out of the earth, it must be piled up in a huge heap or mountain, which slopes off in every direction from the opening. This is always kept clear by explosion, so as to form a great gulf like a funnel in the top of the mountain. The gulf or funnel is called the "crater." A crater may be very large, as for instance that of Kilauea in the Hawaiian Islands, which is two miles long, a mile wide, and 800 feet deep, with a constantly boiling lake of fire at the bottom.

Let any reader who wishes to form some idea of a stream of lava go to see an iron-furnace when the iron is being drawn. The melted metal, so bright that it blinds the eye, spouts out from the opening in the furnace, and rapidly runs down like water into the channels made in the sand to receive it; but the farther it goes the cooler it gets. It soon becomes sticky and covered with scum, and by and by it only creeps along. So the

CRATER OF KILAUEA, HAWAIIAN ISLANDS.

lava soon cools, the surface "rises" like yeast, and becomes spongy and hard, and cracks up, and, at a distance from the source, the lava-stream looks like a river of furnace-clinkers moving slowly along, the fragments on the surface rolling over one another with a rattling noise.

There are volcanoes all over the world. They occur all along the Pacific coast, on the western side as well as the eastern, all the way from Bering Strait to New Zealand. There are volcanoes in Africa, in the Mediterranean, the West Indies, and even amid the eternal ice and snows that surround the southern pole. Iceland is especially noted for its volcanoes, which have burst forth from time to time in the most fearful eruptions. On one occasion the volcano of Skaptar Jökull poured out a stream of lava which, flowing into the bed of a river, dried it up. The flowing lava followed the bed of the river until it came to a lake, which it filled up, and, soon after, it reached a tremendous abyss over which a magnificent waterfall had formerly plunged. Here, too, the lava took the place of water, and formed a cataract of fire which must have been a grand and awful sight.

Of course all volcanoes are not of the same age. Many have been formed within the last few centuries, and we have descriptions of several from eye-witnesses who watched their formation.

About the middle of the eighteenth century, on the elevated plain of Malpais, in Mexico, lived a planter by the name of Jorullo (pronounced Horool'yo). All had gone along quietly enough in that neighborhood up to June, 1759, when, under the plain, were heard terrible subterranean noises. Then earthquakes followed, and continued for two months, and presently the ground burst open, a terrific eruption took place, and a volcano was formed upon Señor Jorullo's plantation. When Humboldt visited the spot about forty years afterward, he found, in addition to the principal volcano, an immense number of little oven-like vents scattered over the plain, and still hot and smoking.

Just to the north of Naples in Italy is the beautiful bay of Baiæ, on which anciently stood a little town called Tripergola. In the years 1537 and 1538 a great many earthquakes were felt in the vicinity, but on the afternoon of Sunday, the 29th of September, 1538, fire burst out of the ground, ashes, mud, and stones were hurled out, and, in a single night, a volcanic mountain 440 feet high was thrown up, very near the town. Its fires speedily died out; the Italians call it Monte Nuovo, or the New Mountain.

Tremendous eruptions may take place from a volcano without an accompanying earthquake, and the vicinity of an active volcano may be one of comparative safety, so far as earthquakes are concerned. If you throw a stone into a pond you know that a circular wave, or several such waves,

VOLCANO FORMED ON SEÑOR JORULLO'S PLANTATION, MEXICO, IN 1759.

are formed, which extend in every direction, disturbing the whole surface of the pond. If anything is floating on the water, as, for instance, a chip, when the wave reaches the object, it rises and falls for a moment, and then it becomes quiet in the same place. Similar waves may be formed in iron or wood or rock. When a heavy train is passing, you know how the ground jars and shakes, even at a considerable distance. This is because waves are formed in the ground like those formed in the water when disturbed by the fall of a stone. Now if, owing to some disturbance below, the rock-crust of the earth should suddenly rise or fall or be shaken, waves would start off with tremendous rapidity in every direction. When these waves pass under a place they jar or shake it, more or less severely, causing an earthquake or earth-tremble. Some of these waves in the rock are several feet high, and as they move at the rate of from thirteen to eighty miles in a minute, when they pass under a town it may be shaken down or tossed up, like the men on a chess-board when one gives it a rap underneath; and in the twinkling of an eye the largest buildings may be overthrown. Sometimes the earth jumps up beneath the feet, sometimes it sinks suddenly down, and sometimes the motion is from side to side, so that trees lash the ground with their tops. There is something inexpressibly dreadful about an earthquake. There is the sudden subterranean thunder, then the violent shaking of the earth, the crash of falling buildings, and the cries of affrighted men, women, and children rushing hither and thither for safety. But where is safety to be found when the earth itself is rocking?

MONTE NUOVO, ITALY, FORMED DURING A SINGLE NIGHT IN 1538.

Earthquakes sometimes disturb the sea and cause the formation of immense waves, which pass across entire oceans and break upon the shores to a height far above that reached during the severest storms. Earthquake-waves following earthquakes have done terrible damage to cities and settlements on the shores of Chile and Peru, the Hawaiian Islands, the West Indies, and in various other parts of the world. They show what mighty force is in the earthquake.

II

By Professor Frederick D. Chester

It may be asked, why do we speak of volcanoes and earthquakes in the same breath? I answer, because the two are as closely related as a boiler and its safety-valve. After the great earthquake of July, 1883, upon the island of Ischia, in the Mediterranean, Mount Vesuvius, which lay just across the Bay of Naples, began to smoke and discharge lava. The same thing occurs after nearly every earthquake, if there is a volcano near by. The earthquake comes first, and then the volcano sends out its steam with a hissing, growling noise, very much as steam escapes from the safety-valve of a boiler. Now, a safety-valve is for the purpose of relieving the boiler when there is danger of its bursting because of an excess of steam-pressure. For similar reasons, when there is too much steam in the earth, there is danger of an explosion, and in all real earthquakes the ground quakes, heaves, and splits because of these explosive shocks, until the volcano opens its valves. Then the earthquake ceases. So the volcano is the safety-valve of an earthquake.

Geographies sometimes tell us that a volcano is a mountain from which issue smoke and flame; but this is not correct. When you see pictures of dark, curling pillars or clouds of what appears to be smoke pouring out of a mountain, be assured it is not smoke, but steam darkened by the flying ashes. The mountain in the picture may look as if it would burn down in a few hours; but this is only an appearance. In reality, the red-hot melted rock or lava is lighting up the clouds of steam, so that they resemble flames of fire. If you have ever seen the fireman of a locomotive open the fire-door at night, you may remember how the

steam was illuminated until the whole engine seemed ablaze. This will make you understand why active volcanoes appear to be burning.

But a volcano also throws out immense masses of stones, ashes, cinders, and lava. Imagine a single volcano pouring out at one time enough of all these things to make a pile as large as three Mont Blancs!—or another throwing out enough material at a single explosion to cover all of Germany two feet deep!

Now, let us consider how so much rock gets melted, and whence so much steam comes. You know, even if you have never tried it, that it takes a great deal of heat to melt a rock; as much as it takes to melt iron and copper. Many rocks can hardly be melted. The hardest way to melt a rock is to dry it in an oven, and then put it in a furnace. But there is another way to do it, whereby it requires but one quarter as hot a fire. A piece of cold lava, such as may have been brought from some volcano as a specimen, is broken up fine, and mixed with water until a stiff mud is formed. Then a strong steel tube, closed at one end, is filled with the mud, after which the other end also is closed, and the whole put into the fire. Experiment has proved that the mud thus confined will not require nearly so hot a fire to melt the particles of rock, as would be necessary if the latter were dry. But, you say, how can this be?—for wet things resist the action of heat better than dry. The explanation is probably this: the water in the mud which you put in the thick steel tube changes, when heated, into steam, and this steam, having no means of escape, is under great pressure. While ordinary steam, such as comes out of the spout of a tea-kettle, is very hot, and is capable of dissolving rocks very slowly, steam which is under great pressure, as in the tube, becomes much hotter, and has therefore greater power to dissolve substances. Considering this, we can see why the steam confined in the tube should easily dissolve some of the rock, and that a portion of it being thus dissolved, the remainder would more easily become liquid, just as the melting of a small portion of butter hastens the melting of the rest. We shall find that rocks which lie deep under the ground are melted in much the same way as are the particles of lava in the tube, but with this difference, that the water in the former case is under such pressure that none of it can ever turn into steam.

You may ask why the water is under so great a pressure. You must remember that where the rocks are melted is at a depth of at least four or five miles, and that all water in the rocks at this depth would therefore be pressed upon by rocks four or five miles in thickness. If you consider what a pressure is brought to bear upon the lowest stone of a great tower by the stones above, you will better understand why water at great depths is so confined that it cannot become

VESUVIUS IN ERUPTION. (BY PERMISSION, FROM "THE NEW ASTRONOMY," BY PROFESSOR S. P. LANGLEY.)

steam. If you were to go down into a mine, you would find that the deeper you penetrated, the hotter it would be. In one great mine in Nevada the air is so hot that it is necessary to pump down cold air so that men may work in it. Deeper still, it probably is hot enough to melt the rocks.

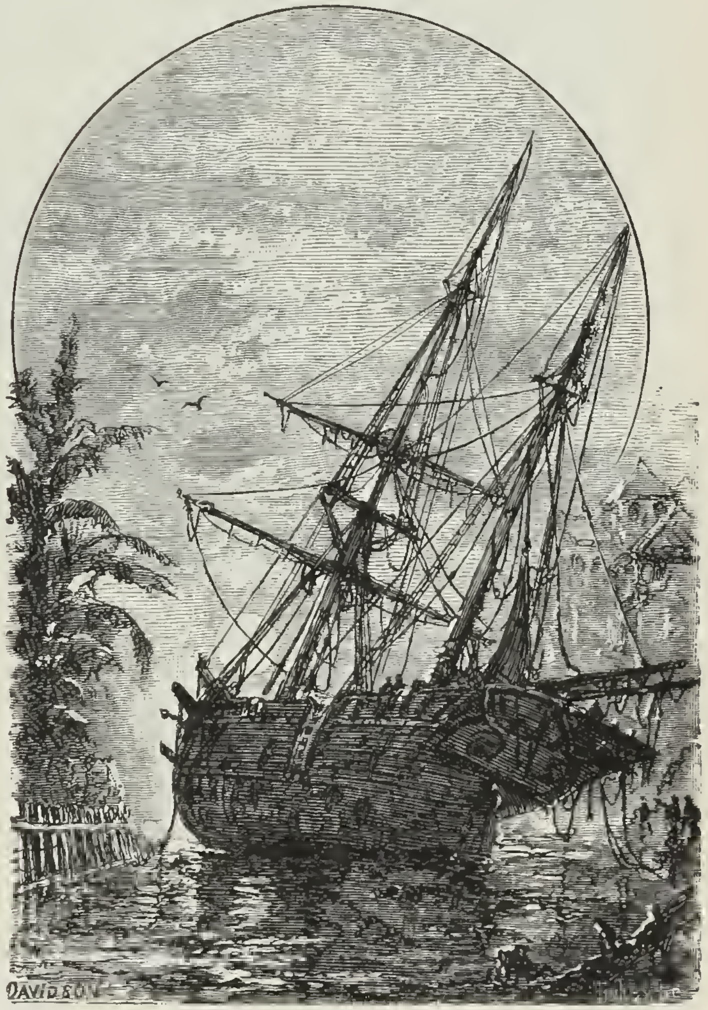
But there is another fact to be learned. When it rains, some of the water soaks into the earth and through the rocks, by different ways, until it reaches hundreds and thousands of feet below the surface. So much is found in some deep mines that it would require many fire-engines to pump it all out as fast as it comes in.

We are now prepared to learn more about volcanoes. A volcano is often declared to be a mountain; but this is not always the case. We learn from geology that most of the ancient volcanoes, before men were created, were not mountains at all, but merely cracks in the ground, from which proceeded steam, melted rock, and other matter. But if an opening in the ground keeps pouring out melted rock, it makes a vast accumulation of lava about the crack, until it may build up a real mountain. As the steam always tries to escape upward through the fissure it forces the lava up with it until the crater is full, and looks like a lake of fire, or a great kettle of red-hot slag. Just before the volcano pours out the melted rock, it often acts as you may have seen porridge do when it is cooking on the stove. The porridge gurgles and bubbles, and the surface heaves as jets of steam escape. It then sinks, and rises again a little higher than before, until, if you continue the heating, the porridge may rise so high that it boils over and runs down the sides of the kettle. The porridge gurgles, bubbles, and heaves because the steam is trying to escape into the air; and, as the steam seeks the air through a great lake of lava, the latter bubbles, gurgles, and heaves, just as the porridge does, until it boils over and runs down the sides of the mountain like a river of fire. Besides the noise made by the boiling lava just before an eruption, there are sometimes all sorts of other terrible sounds heard. The steam often escapes with a deafening hiss, as if many locomotives had opened their valves at once; and again, it has such power that stones, cinders, hot lava, and sometimes even pieces of the mountain, are thrown far into the air, to fall again with a tremendous rattling noise.

It is a well-known fact that the action of volcanoes is not continuous. Generally the crater is in a hardened condition, from the cooling of the lava, and steam is emitted only in places where the lava melts again. But after slumbering for years, the awful thing will suddenly awake anew, and pour out a flood of fire.

What is the cause of this period of inaction? The steam has been exhausted, and a period of eight or ten years or more may elapse before the earth can again have absorbed sufficient water to make steam enough for sending out the lava.

We are now ready to speak of the earthquakes, and discover, so far as we may, how they are caused and what they are. I have already mentioned the dreadful earthquake of July, 1883, that occurred upon the little island of Ischia, fifteen miles across the bay from Naples. It was nearly ten o'clock on a Saturday night. The week's work was done. The fishermen had drawn up their boats on the beach, and were in their homes.



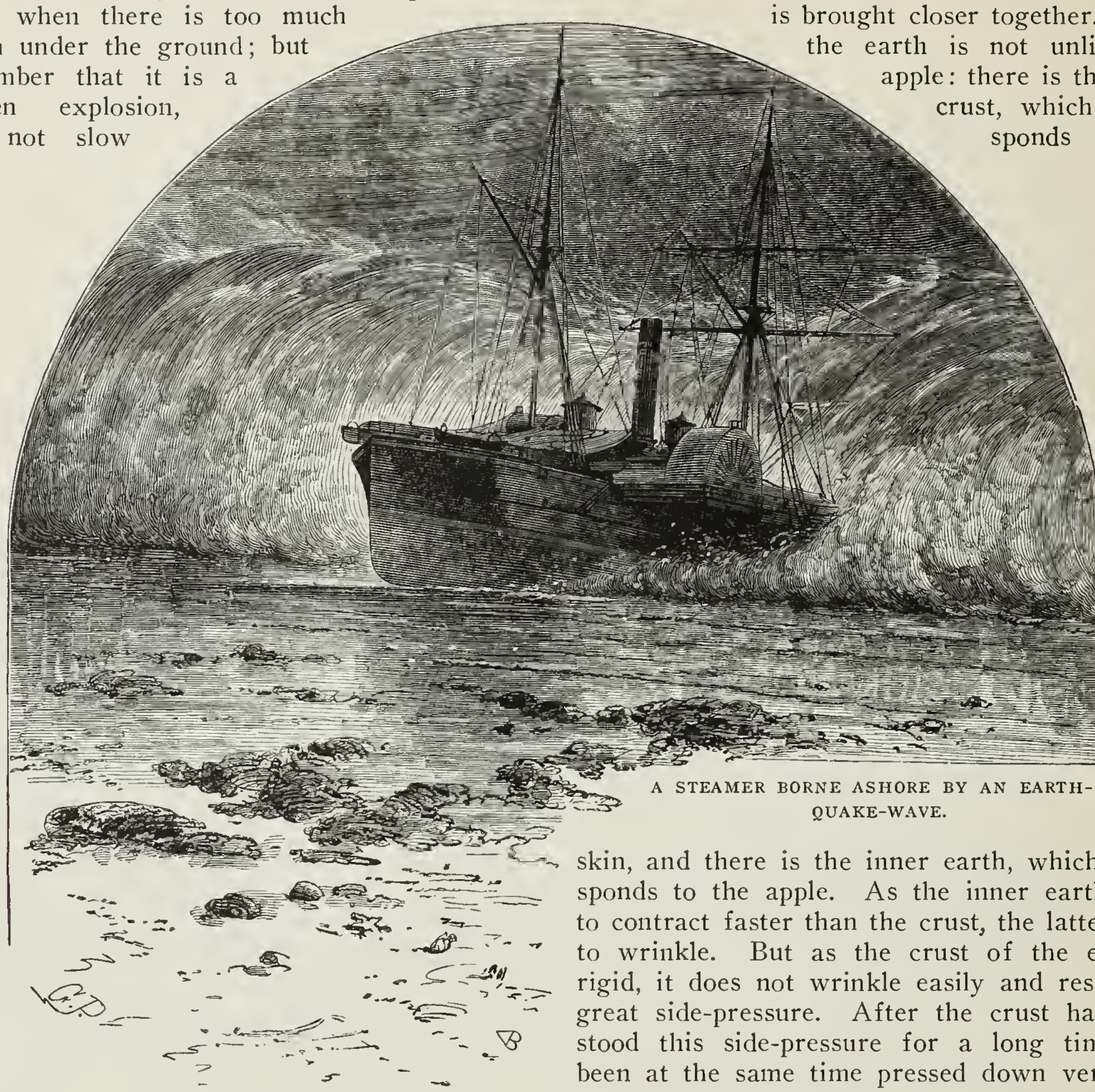
A VESSEL LEFT FAR INLAND AFTER THE PASSING OF AN EARTHQUAKE WAVE.

Hundreds of picturesque hotels and cottages nestled peacefully amid the tropical foliage. The hotels were thronged with visitors, and the theater was crowded.

Suddenly a tremendous shock was felt, and a sound heard like the thundering of a train over a bridge. Two more shocks followed, and all was over. In the space of fifteen seconds three towns had been destroyed and thousands of people had lost their lives. And yet this shocking occurrence

by no means equals some similar calamities where far larger tracts of country and cities with tens of thousands of inhabitants have suffered.

We have already said that an earthquake takes place when there is too much steam under the ground; but remember that it is a sudden explosion, and not slow upward pressure. Supposing there were a hundred boilers, or more, buried four or five miles beneath the surface of the earth, and that they should all burst: we should have a result similar to an earthquake. The ground would shake, heave, subside, and even crack open in great fissures. You would hear a noise which might be low and muffled, like thunder, or a sound like that of the earthquake at Ischia.



A STEAMER BORNE ASHORE BY AN EARTHQUAKE-WAVE.

Again, the crust of the earth is not wholly stable, but continually rises and sinks; this country, for instance, subsided eight or ten miles during one epoch of geological time. Not only is the crust subjected to a great *downward* pressure, as a result of its enormous weight, but also to a still greater pressure from the sides. You know how apple-skins wrinkle when they are baked; that is because the apple under the skin shrinks when the juice cooks out; as the skin does not contract as fast as the apple, it wrinkles when it is brought closer together. Now, the earth is not unlike the apple: there is the outer crust, which corresponds to the skin, and there is the inner earth, which corresponds to the apple. As the inner earth tends to contract faster than the crust, the latter tends to wrinkle. But as the crust of the earth is rigid, it does not wrinkle easily and resists the great side-pressure. After the crust has withstood this side-pressure for a long time, and been at the same time pressed down very hard by its own weight, it may suddenly break with a snap, and a terrific jar is the result. In many earthquakes, the violent crash is followed by a sudden sinking of the ground, which buries whole towns. This is because the crust is broken, and sinks rapidly by its own weight.

So earthquakes may be caused in two ways: first, by the explosion of steam beneath the surface of the earth; second, by the sudden snapping of the earth's crust. Either of these, of course, would jar the surface of the earth. Sometimes it shakes back and forth, or up and down; sometimes it rocks like a cradle; but the usual effect is a trembling motion, produced as if by some great shock dealt from below.

While we usually think of earthquakes as taking place on land, they do, indeed, occur with

KRAKATOA IN ERUPTION.

equal devastation in the ocean. That point in the earth at which the explosion or breaking takes place is called the earthquake-focus; and from it what are known as earthquake-waves pass

REMAINS OF KRAKATOA AFTER THE ERUPTION.

to the surface. What do these earthquake-waves resemble? Take a basin full of water, and dip a glass tube in it. Blow through the tube and you will see bubbles rising to the surface, and circular waves passing out. The disturbance at the bottom of the basin corresponds with the explosion or snapping of the crust at the earthquake-focus, with this difference, that instead of water-waves the latter produces earth-waves, passing through the ground. When the city of Lisbon, Portugal, was destroyed, the earthquake took place in the bottom of the sea, fifty miles west of the city. Yet it so agitated the water that a wave sixty feet high dashed over Lisbon, destroying it and its inhabitants in the space of six minutes. Another earthquake, occurring just off the coast of Peru, made such a gigantic wave that a large vessel was thrown several miles inland. These are called earthquake-waves. They are the largest known waves, and are caused by the heaving and rocking of the bed of the sea. In deep water such waves are not very high, but their motion extends far down into the ocean. When they reach shallower water, however, they heap up like a gigantic wall, and, with a force more terrible than fire or sword, they sweep on, bearing destruction with them. Huge ships are tossed like straws far inland, or mingle their ruin with that of a harbor town.

The terrible volcanic eruption of August, 1883, which occurred off the coast of Java, caused the sudden destruction of thirty-two thousand people, as the disastrous waves engulfed the coast, destroying the homes of the natives. If you will look at a map, you will see that the island of Java runs in a nearly east and west direction, and that it is separated from the island of Sumatra by a channel of water called the Strait of Sunda. In this strait, adjoining the west end of

Java, are a number of volcanic islands, one of which is known as Krakatoa. Krakatoa, which is but a volcanic mountain rising from the sea, began to be in eruption in May, 1883.

At that time the steam escaped from the crater in puffs, sometimes white, sometimes gray or black with ashes, much as it does from the stack of a locomotive. Viewed from afar, this steam apparently rose to a height of thousands of feet, where, caught by currents of air, it was spread out over the mountain in a vast canopy of cloud. This, however, was but a preliminary operation. The great eruption, with its attendant earthquake-waves, did not begin until August 26. At about four o'clock in the afternoon of that day a series of reports, like the firing of heavy cannon, were heard proceeding from Krakatoa. These reports, becoming louder and louder, continued until night, when a thunder-storm, accompanied by a high wind, arose. The air was thick with falling ashes, and the sea, agitated by earthquake-waves, put all vessels into deadly peril.

Enveloped in the unnatural darkness, but hearing the advance of the waves, the natives on shore sought refuge in the mountains. All through the night these appalling waves were heard. Throughout the morning the rain of ashes continued, and by noon the entire coast was plunged in complete darkness.

The violence of the earthquake-waves increased, and at about two o'clock in the afternoon appeared in the neighborhood of Krakatoa the largest wave of all. Approaching the southwest coast of Java, it rose to a height of over one hundred feet, passing over and totally destroying the lighthouse of Anjer, a tower 151 feet high, besides overwhelming many towns.

The same great earthquake-wave passed over a neighboring island known as "'Thwart the way" and converted it into six rocky islets.

THE ISLAND "'THWART THE WAY," BEFORE THE PASSING OF THE EARTHQUAKE-WAVE.

SIX ISLETS FORMED FROM THE ISLAND "'THWART THE WAY," AFTER THE EARTHQUAKE.
(FROM SKETCHES BY CAPTAIN JOSEPH T. CONANT.)

THE WORLD IN THE WATERS

We know that all life began in the sea, but life did not leave the sea forever. There is still more life in the depths of the ocean than on the land. The sea teems with unnumbered forms of life—life as simple as that which first swam in the waters, and life as wonderful as that of the whales and dolphins and seals. There are fishes that sail through the air so high above the water that we call them flying-fishes. There are fishes that can crawl out of the water and walk overland. There are fishes that build nests at the bottom of the sea, creatures that build islands and sea-walls; and in cliffs and mountains we find myriads of skeletons of tiny creatures that once lived and breathed on the ocean-bed.

Not the wisest men on earth know the full story of the sea and its wonders. How can they? They have to seek knowledge from the things that their dredges bring up. That is as if we set to work to examine some great, deep lake by bringing up things from its depths in a teaspoon. However, patient work is constantly bringing new learning to us. We know that there is no place in the ocean where life is not possible. The waters of the equatorial regions and the seas of the temperate zone abound with life, and so also do the silent waters of the frozen arctic circle.

Nature will have no blank spaces. There is a place for everything, and we find everything in its place. We find, swimming upon the surface, creatures that cannot go far down into the ocean. In the middle depths we find fish that cannot come to the surface lest, without the proper pressure of water upon their bodies, they should burst. Those same creatures cannot descend below a certain level; and still lower down are creatures that never see the light, fulfilling in the unlit depths of ocean the purpose for which they were created.

For the present it will be interesting for us to glance at some of the lowest forms of life in the sea. We shall find it as wonderful as anything in the whole of Nature's fascinating story. Let us consider the marvels of that class of tiny organisms called *Infusoria.* They exist in fresh water and in the water of the sea. In a single cupful of pond-water, such as certain infusorians like, there may be more of them than there are people in the whole world. The rate at which they increase is astounding. One infusorian breaks up into two; two become four; four become eight; eight become sixteen, and so on, almost as we watch.

Given the proper temperature and nourishment, a single infusorian may become in four days the ancestor of a million like itself, in six days of a billion, in seven and a half days of a hundred billions. From that tiny speck we have in seven and a half days this countless host, weighing over 200 pounds. Of course, the numbers do not work out like this, for there are merciful checks, or the whole earth and its seas would not hold the creatures that are born.

Floating upon the surface of the sea, and stacked high over its bed, are countless billions of these and similar tiny creatures, dead and living. Of what are the white walls of England, the beautiful chalk cliffs, composed? Of nothing but the shells of the tiniest little creatures, which we call *Foraminifera.* They were all living creatures millions of years ago. They were born and had their day, and they died, piles upon piles of them, and their shells turned to chalk. And other white cliffs, which will some day rise above the waters, are still being built up beneath the sea to-day. The tiny specks of life in their little shells are still being born, and are still dying, down in the sea, and they are forming ooze which will some day be solid chalk. It would take about ten millions of them to make a pound of chalk, but enough of them have lived to make millions of tons of chalk.

INSECTS THAT BUILT UP THE STONES OF PARIS AND BERLIN

Some of the greatest European mountain ranges, the Alps and the Balkans, consist largely of the shells of little creatures like these, called nummulites. Among the greatest wonders in the world are the Sphinx and the pyramids in Egypt, built of dead nummulites. They grew in seas where there is now dry land. They formed the Arabian chain of mountains; and from these mountains men cut the great blocks of which the Sphinx and pyramids are composed. Paris is built of stone from a similar source, and Berlin stands upon foundations made up entirely of the skeletons of tiny animals.

In view of all this, we shall not be surprised to learn of the wonders of the coral-builders. These are very tiny sea-animals, which appear in their glory only in the warm waters of sunny seas.

THE LITTLE CORAL-BUILDERS THAT WORK DOWN IN THE SEA

Long, long ago, men had been in the habit of bringing coral up from the sea in nets and by other means. The common fishermen could not be expected to know a great deal about its composition, but wise men thought they knew more, and they all agreed that coral was simply a sort of rocky flower grown in the sea. But how could a flower be hard? That was quite simple, they said. The fishermen told them that coral, when in the sea, was quite soft like any other flower, but that as soon as it reached the air it became as hard as rock. And for ages that was believed. But a man who wished to know more sent down a diver, who found, of course, that coral beneath the waves is as hard as coral above the waves. This careful investigator could not believe the word of his diver, but went down in the water to find out for himself.

We know now that the coral-builder is one of the tiny, tireless workers of the deep. The coral animals are as numerous as the stars of heaven. When born, they are quite soft, jelly-like little things. But they have the power to extract carbonate of lime from the sea-water, and to build with it the most wonderful structures to live in. As bees make honey, so the coral animals make lime, from their own food. They build homes of coral for themselves. A number of them work together, and they make their houses join by neat canals or passages. But there are many forms which the buildings take.

THE ANIMAL WALL THAT RISES FROM THE SEA-BOTTOM

Some form the loveliest structures that look like flowers. The colors are not always the same. There are browns and blues and greens, as well as the more common pink. This coral home is not made as a bird makes its nest, not as the mud plaster in which the rhinoceros loves to bury himself in a swamp; the coral is part of the coral animal itself. It issues from the soft interior of the little animal's body, and is its stony covering.

Countless hosts of coral insects working together join their skeletons or coverings to each other. They build upward from the bottom of the sea, until they reach the top of the waves. They make great reefs or barriers in the sea where before the waves flowed unchecked. The coral insects build islands. They put a great ring of coral round a tract of water, and make a lake within the boundaries of their work. In places where they are most numerous they quite change the character of the sea. The structures are the actual coverings of the coral insects' bodies. They become solid rock, forming dry land for thousands of miles in the sea.

We know how very difficult men, with all their skill and all their fine tools, find it to build a lighthouse in the sea, but here these tiny animals, working in the depths of the furiously tossing waves, build structures which have no likeness in the world. One of their works consists of a barrier reef along the shores of New Caledonia, 400 miles long, and another, along the northeast coast of Australia, 1000 miles in extent. As a great man points out, this means a work by these tiny creatures beside which the Great Wall of China and the pyramids of Egypt are like children's toys. The work has been going on for many ages, and it is going on to-day. Of course, the result is sometimes serious to ships, which run on to the coral reefs and are wrecked. But that should seldom happen, as we have charts of the seas to guard our sailors against wreck in such ways.

LIVING AND BUILDING AND DYING IN THE BLUE SEA

If they do damage in this manner, the coral-builders are friends to mankind in another way—they provide homes for men where only the sea once appeared. Sea-worms of various sorts bore into the coral and loosen it, so that the waves break it up. The great waves pick up huge blocks of the loosened coral, and throw it high up on the reefs, grinding much of it to powder. Shells and sand collect and are ground up together by the action of the waves. The powdered mass collects in the crevices of the reef, and presently seeds blown from afar, or carried by the sea, or brought by birds, take root in the soil that has been slowly forming. Entire trunks of trees, that have been torn up and carried down rivers and out to sea, find a lodging here. With these trees come small animals, such as lizards and insects. Trees grow; sea-birds settle; tired land-birds, blown out to sea, take rest; and at last man comes, to find trees and fruit and birds and other forms of life. Here is a home all ready for him. But the creators of it were the myriads of coral animals, living and building and dying in the blue sea.

Growing on the coral reefs and adding to their beauty, we find a great many sea-anemones. At first we might say that these are vegetable growths. Their very name suggests it.

THE LIVING FLOWERS THAT GROW ON THE LIVING WALLS OF THE SEA

THE wood-anemone, the plant, we all know. But the anemone of the sea is an animal that can kill and eat other forms of animal life, and, by some process too mysterious for us to understand, can enter into partnership with other animals, just as birds enter into partnership with crocodiles, buffaloes, and rhinoceroses. This animal-plant or plant-animal grows in the most elaborate and gorgeous forms. A fairy wand could not create more charming pictures than the anemones present. Some of them appear to have a sense of sight, for what look like eyes appear. They depend, however, chiefly on the sense of touch for their food. They have long, sensitive feelers, which look like petals or fringe. When anything fit for an anemone to eat touches them, these feelers close like a flash upon it, and draw it down the tube leading to the anemone's stomach.

Let us watch them in a sea-aquarium. The anemone, glistening and gay, grows at the bottom of the water, or on the side of the glass, like some extraordinary fringed mushroom with its head the wrong way up. There is nothing to suggest that this is a hungry little animal. But wait.

THE ANEMONE AND THE CRAB—THE CRAB AND THE SPONGES

A LIVELY shrimp darts through the water. The tentacles of the anemone are instantly all of a quiver, ready to catch the little shrimp. The shrimp's instinct tells him what that means, and he darts away if he can. But he cannot always do so. The anemone must live and have his shrimps, or other form of food, and the tentacles close in rapidly, causing the anemone to shut up like a flower going to sleep for the night. And if the effort made is quick enough, the poor shrimp is encircled by those terrible tentacles, and drawn in to make a good meal for the hungry anemone.

There are countless anemones growing upon our seashores. Some look like rosettes, others like mushrooms with a fuzzy top. The fringe of tentacles lies widely expanded, and we should never dream how quickly they can move. Let us touch the top of the anemone with a finger. It closes at once upon our finger, and we feel that each little spike of the fringe is roughened at the end, and gives a distinct pull at our finger, like the rasped claw of some insect. They are not strong enough to take in our finger, but they have received the necessary impulse which sets them at work. The anemone shuts up, apparently believing that it has caught a meal, and for some minutes it will not attempt to reopen.

It is a humble form of life, yet there seems so much purpose and plan about the ways of the anemone that we are bound to confess ourselves amazed and bewildered at such apparent method and skill. But the wonder only begins here. The partnerships of the anemone are the most wonderful feature of its life. Let us consider them for a moment. The hermit-crab, while a vicious, quarrelsome little rascal, has no shell to cover his tail. That is the spot which his enemies attack. His one hope in life is, therefore, to win and retain a secure covering for his unprotected tail. He and the anemone seem to come to an agreement. The anemone affords him just the cover that he needs for his tail, and he in exchange carries the anemone about on his back.

The tentacles of the anemone are toward the nippers of the crab, and when he goes in pursuit of prey, the anemone helps to kill it. The anemone has stings which paralyze or kill a little living animal. The crab has, therefore, a powerful ally to help him in killing his food, and as he eats, the anemone shares his meal. It is a profitable partnership. The crab gets his tail protected; he is largely hidden from his enemies; he is hidden, too, from the things that he desires to attack. The anemone is carried about, and is kept in constant touch with an ample supply of food. Thus we have a life partnership between the simple-looking plant-animal and a desperate warrior who is always battling.

The study of anemones is a most interesting one, and one which many can pursue, for they abound wherever rocks strew our shores. Think of them not as plants, but as animals, of which the larger will swallow a shell the size of a saucer, and then divide into two living animals rather than lose the booty it has managed to secure.

The anemone is not the only sea-animal with which the crab goes into partnership. There is a certain sponge in which he makes his home. We know that sponges are not vegetables, but animals. They admit the sea-water through the canals in their bodies. From this they extract tiny forms of life for their food, and at the same time take for their breathing the oxygen which the water contains. That is the way fishes breathe. They have gills, over and through which the sea-water washes. These gills take the oxygen from the water and pass it into the blood-vessels, so that the fishes may breathe as we breathe. The method is, of course, very dif-

ferent, but the purpose and result are the same. That is the way in which the sponge, no matter what its name or size, breathes and feeds and grows.

In some of the channels running through the sponge may be found the hermit-crab. Higher up in the same channel may be discovered a little shell, and also a little worm. In this collection we have the history of four forms of life. First of all, the hermit-crab pops his naked tail into the empty shell left by a growing whelk. Then comes a young sponge, sent forth on its life journey by its parent. It settles upon the whelk-shell in which the crab has sheathed his tail. There the sponge grows and grows until it quite covers the shell, leaving open a channel by which the crab can enter and leave. As the sponge and the crab grow bigger they take into partnership a little worm, which is admitted into the interior of the sponge so that it may devour any refuse which collects in the home of the crab. Even such humble things as crabs and sponges have to guard against unclean homes. That is why we find the interior of the sponge occupied by a shell, a worm, and a crab.

THE BRILLIANTLY COLORED FISHES OF CORAL REGIONS

Where corals abound, fishes of the most brilliant color are always to be seen. The fishes protect themselves by becoming colored like their surroundings, just as the animals do. But swimming with them are marvels of colored jelly, apparently. They are the jellyfishes. We all may see jellyfishes at the seaside when the tide goes out. Better still, on a favorable day, we may see hundreds of them floating on the sea as we travel by steamer. They look like great white or transparent leaves, with a little dash of red in the center as though they had been darned with colored wool. The jellyfish of brilliant color belong to the warm seas of the tropics. But the nature of all jellyfishes is much the same.

Those of the tropics give off a brilliant silvery light at night, which helps to make the sea like a gleaming mirror of liquid metal. If we catch one and lay it on a piece of blotting-paper for examination, we have to be very quick, for the jellyfish is composed largely of water, and it simply dries up before our eyes. They are not nice things to handle; they can sting very badly, as all sea-bathers know. The scientific name of the jellyfishes and their kin is taken from the Greek word which means nettle, and sea-nettles is another name for the jellyfishes that sting.

By far the most alarming of the sea-nettles is the Portuguese man-of-war, or physalis. This looks like an inflated bladder, six inches long. Beneath it stream a number of organs, important to the animal in gathering and distributing food. The tentacles that we most wish to avoid are those which carry the stings. These are intended to numb the prey of the physalis, but woe to the man who comes in contact with them. They flow out some feet from the body of the animal, and are heavily charged with stings and a poisonous fluid. The merest touch from them will raise a white swelling on the hand, and for long afterward the hand and arm experience an aching pain, which gradually extends to the muscles of the chest, causing some trouble in breathing. Even when they have been removed from the body of the physalis the stinging cables retain their power to injure, and from them issues a fluid which, after lying upon cloth for some days, still has power to sting.

The sea-anemones, the corals, the jellyfishes, and many other plant-like sea-animals, all belong to the same family. We have another interesting family including starfishes, sea-urchins, sand-stars, brittle-stars, feather-stars, and so forth.

THE STARFISH, THAT WALKS ALONG THE BOTTOM OF THE SEA

We have all seen many starfishes at the seaside. There is not a simpler, more innocent-looking thing to be found by the sea than the starfish, particularly that commonest of all, the crossfish, as we call the five-fingered one. Yet it is a really wonderful creature. Its organs are in the center of its body, and the fingers, as the rays are called, branch out from that center. Now, the fingers are really legs, for there are tubular feet underneath them by means of which they walk as comfortably along the sea-bottom as we walk along the beach.

The starfish has a terrible appetite, and oysters, mussels, scallops, and other shell-fish are its food. With its long and strong arms or fingers it seizes its prey, and, no matter how powerful the shell may be, by persistent pressure the starfish manages to force it open, and then eats the fleshy interior. Fishermen hate the starfishes, and when they catch them they tear them in two and fling them into the sea. That is not only cruel, but also very stupid. Though you tear a starfish in halves, the animal can recover. Each of the halves heals and grows new fingers, and instead of a dead starfish in two halves, you soon have *two* starfishes, fully equipped for hunting and very much alive.

THE SEA-CUCUMBER THAT THE CHINESE LIKE

What we call the sea-cucumber is also an animal. Its other names are the sea-pudding, the sea-slug, and the trepang. It has the same sort of feet that the starfish possesses—suckers which protrude from tubes—and can get along over places which seem quite impossible.

The common name of the sea-cucumber suggests the idea which its appearance presented to those who bestowed the title upon it. The Chinese consider it a great delicacy for the table. There are many kinds of sea-cucumber, and the rarest bring quite high prices. It does not seem nice to eat sea-slug, and we are content to leave it to the Chinese. But perhaps they consider the tastes of those who delight in turtle soup quite as strange as we take their taste to be.

We have glanced briefly at some of the lowest forms of life in the sea. It is quite as wonderful as life among the higher animals. We do not expect much of animals that seem to be no more highly gifted with life than plants; but, as we have seen, there is a mystery and fascination about these lowly creatures sufficient to make even the wisest men marvel at their habits.

WONDERFUL ANIMALS IN THE SEA

The age of giant animals has not quite passed away. There are giants still in the sea, so big that the biggest animals on land would seem small beside them. They could not get food enough on land, so they have changed from land animals into sea animals. There, in the vast deep, great whales live their lives amid friends and terrible enemies; and whales are not the only animals which left the land for the ocean. Seals of many sorts pass the greater part of their lives in the sea, but they come to land for a certain time each year. Then they go back, having first taught their babies, which are always born on land, how to swim and hunt for their food in the deep. In reading about Nature's great family of animals, perhaps we may feel a little vexed to think that this is the day of small things—the day of smaller lions, and tigers, and reptiles; of smaller birds and other creatures than once lived upon the earth. But there still live creatures as big as any that the world has known. Not even in the old days, when many creatures were monsters in size, was there a bigger animal than the whale which swims the seas to-day.

"But whales are fishes," you will say. Nearly everybody thinks that. They think that whales and dolphins, and porpoises and manatees and dugongs, are fishes, like the shark and the fishes that we eat. Scientists also thought so many years ago. But these creatures which we have been mentioning are really animals. They are mammals, which, as you know, are creatures that feed their young on milk. The whale is a mammal, like a fox or an elephant.

As whales live in the sea, you would not think that they could be drowned; but they can. They, like ourselves, have to breathe the air of the atmosphere to live. To do so they must come to the surface of the water. You know the cry of the whalers. "There she blows," they cry when they see a monster rise to the surface and spout streams of water and vapor into the air. When the whale comes up to spout, it means that he has been down under water as long as he can, and has been driven to the surface to breathe out the air which has been used up in his body, and to take in a fresh supply.

Now, as he must remain below at great depths for a long time, the whale has a specially developed system of vessels in which it stores up blood purified by the air which it has taken in. This reserve of oxygen it uses up slowly while it is below the surface; and by this wonderful provision it can remain in the depths for a very long time.

For a long time clever men were puzzled to know why the whale has a monstrous flat tail. Most fishes have tails which are upright. The whale's tail is flat. The whale would not be perfect without a flat tail. As it is so huge an animal, much strength is required to drive it through the waters, and still more to raise it from a great depth to the top of the water. Fishes have gills with which they breathe the oxygen actually in the water. Whales must breathe in the open air itself. The fishes are quite well served by their upright tails, which steer them through the waters when they are swimming horizontally or flat in the water. But the whale wants suddenly to bound from the depths of the ocean to the top of the waves. His immense flat tail, which measures about 18 feet across, is the lever which lifts him. With two or three movements of this tail he drives himself to the top of the sea, to breathe and blow and spout to his heart's content. This is why the shape of the whale is different from that of most fishes.

A WHALE THAT WAS BURIED FOR THOUSANDS OF YEARS

Once upon a time, ages and ages ago, whales were probably like frogs, in the sense that they could live either on land or in water. They were,

most likely, great hairy animals with four legs. Some of them were armored like the crocodile. The remains of whales of other ages are so numerous, buried in the earth in parts of our country, that farmers occasionally find their bones. Many years ago the remains of a whale were found embedded in a cliff on the sea-front at Brighton, England. A storm had washed away part of the cliff, and fishermen found a bone 9 feet long sticking out of the cliff. When the remains were examined they were found to be those of a whale over 70 feet long, which had died thousands of years ago.

Not all whales have teeth—the whalebone-whales have none. But the baby whales all have teeth, showing that long ago all whales had these weapons. The main difference between various kinds of whales to-day is in the matter of teeth. That difference is important, because it decides what food the whale shall eat. One sort of toothed whale, the grampus, has such good teeth that it has become a cannibal. Not content with cuttlefish, huge jellyfish, and seals, it eats other whales. The toothed whales include the sperm-whale, the bottlenose, and lesser sorts. The whale without teeth, called the baleen-whale—that is, the whale which furnishes whalebone—is the most valuable of all whales. The whalebone is worth over $10,000 a ton.

A WHALE'S MOUTH IN WHICH A BOAT COULD FLOAT

Let us try to picture a baleen-whale. An average size for such a whale is from 60 to 70 feet in length, and from 30 to 40 feet round the thickest part. The head is about 20 to 25 feet long. On top of the head are the two nostrils, placed there so that the whale can breathe the moment it comes to the surface. The nostrils can be closed by valves, which keep the water from entering the nose and reaching the lungs. On its back the whale is of a dark color, so that, with the light shining down through the water, the back of the whale looks like the water itself. Underneath the whale is light in color.

The mouth of the whale is the biggest in the world. When the jaws open it looks as if the huge head had split in two. The length of the jaw is about 16 feet; it is 7 feet across, and, when open, the space between the lower jaw and the roof of the mouth is a good 12 feet. Thus a ship's boat could go comfortably into the open mouth of a whale. But this great cavern is more like a jungle than a cave. This whale has not a tooth in its head. The lower jaws are smooth and polished, but from the upper jaw hangs the famous baleen, or whalebone.

THE WHALEBONE IS THE WHALE'S GREAT FISHING-NET

The whalebone which you buy is not cut from the body of the whale; it is the network of plates hanging down from the roof of the mouth. A cow has hard, broad ridges on the roof of her mouth. So has the whale, only here they are greatly enlarged. The plates are thick and solid where they grow out of the roof of the mouth, but they taper away, and at the ends appear like hair. That is really what they are—plates of hair hardened into a sort of horn, fringed at the end. Of these plates there are from 300 to 400 on each side of the upper jaw, and their weight, in a big whale, is a ton and a half.

What is the purpose of this great mass of whalebone in the monster's mouth? The mouth of the baleen-whale is his vast fishing-net. Although he is the biggest creature in the sea, this whale eats the smallest creatures, chiefly little jellyfish. He has to catch these in shoals to satisfy his appetite, otherwise he would starve. So he swims into a great shoal of the things which form his food. How does he find them? He can see, and probably he can smell. When he reaches a shoal of eatable things, he charges right through it, with his mighty mouth open. The tiny jellyfish are taken in crowds into his mouth. The great jaws close like a drawbridge. The whalebone folds back toward the throat. In the forest of horn and hair are the fish and other things which he has caught. As the whalebone sinks back, these drop down to the whale's tongue, and the water squirts out at the sides of the mouth. Then the whale swallows his "catch."

TINY FOOD FOR THE LARGEST MOUTH IN THE WORLD

The reason for all this is that the whale must have tiny things to eat, because its throat is so small. Big men could stand upright in the mouth of the whale, but its throat is so small that it could hardly admit a man's fist; while the tube down which the food passes to the stomach is only about as thick as an ordinary walking-stick. The throat is fitted with muscles which cause it to close up like a spring trap after the food has been admitted. So much for the mouth.

The body itself is peculiar and wonderful. Over all is the thick oily skin. It is oily so that the friction of the waves may be lessened. Un-

derneath there is a second skin, which gives the whale its color. Still lower there is a third covering, the blubber-oil and solid fat. It forms a great blanket round the whale, in places 2 feet thick. This blubber weighs quite 30 tons, which is as much as the weight of nearly 500 men.

WHY IT IS THAT THE WHALE IS THE FINEST OF ALL DIVERS

The oil and blubber serve a double purpose. In the first place, they keep the whale warm—for the blood of the whale, remember, is warm like ours. Next, they act as a protection against the force of the waves. Our best men divers cannot go down more than a few score feet, and the finest ships made for descending into the depths of the sea go only a comparatively little way, because the pressure of the water is so enormous. But a whale, after having taken a breath, will plunge a mile deep, and at that depth the weight which it has to bear upon its whole body is some 211,200 tons, or over 137 tons on every square foot of its body. Nothing else can bear such a pressure. Some fish which live low down in the water burst when brought to the surface, because the pressure necessary to keep them whole is removed. Other fish, if forced deep down into the water, would be crushed by the weight of water which they would there have to support. But here we see that the whale, thanks largely to its blanket of springy blubber, can bear the pressure of the deep sea, and then come to the top and not be hurt when the pressure is removed.

Men hunt the baleen-whale for its whalebone and blubber. The blubber makes oil. The whalebone is put to many uses. The whale swims from the frozen seas of the north to the warm seas of the south; so the whalebone, when removed from its mouth, will stand all sorts of climates. The best whale of this type is the right whale, called also the Greenland whale, or the bowhead. One of these has been known to yield 1¾ tons of whalebone, as well as 275 huge barrels of oil.

Now we come to the toothed whales. Of these the largest is the cachalot. This has no teeth in the upper jaw, but those in the lower jaw number from forty to fifty, and weigh from two to four pounds each. The jaws are enormous, for the head is nearly a third of the whole length of the body, which, in a large one, measures from 70 to 80 feet. These figures describe the male whales, for the females are smaller. The cachalot is called the sperm-whale. The reason for this is the substance stored in a great chamber of the head. This chamber lies behind the nostrils, from which it is divided by a thick wall of bone, semicircular in shape and several feet high. When a sperm-whale is caught the head is cut open, and men lower buckets into the opening and take out the oil in it. This oil, when refined, gives spermaceti, from which the finest candles and many ointments are made. From one cachalot, which measured only 64 feet, there were obtained 24 barrels of spermaceti and nearly 100 barrels of oil, from which the spermaceti had been refined. Another strange product of the sperm-whale is ambergris. It is a speckled gray, fatty substance, into which the whale changes part of its food, as the civet changes its food into a musky pomade. Ambergris used to be found floating on the sea, and men thought it was a kind of amber, and called it ambergris for that reason. But now we know that it is produced by the sperm-whale, in whose body as much as 50 pounds at a time have been discovered. Formerly ambergris was used for medicine, but now it is used only for scent. Even when it is plentiful, manufacturers pay ten dollars an ounce for ambergris, but when it is scarce they are glad to get it at thirty dollars an ounce. A whale with 50 pounds of ambergris would be worth from eight thousand to twenty-four thousand dollars for this alone, to say nothing of the value of its oil and spermaceti.

THE TERRIBLE SEA-FIGHTS OF THE GREAT TOOTHED WHALES

The value of the whales for whalebone and ambergris, oil and spermaceti, causes them to be cruelly hunted by men, and in some seas where whales used to be plentiful hardly any are now to be found. Luckily, the seas are wide and deep, and there will always be some place to which the whales may go where men cannot find them. But they have other enemies as well as men. The sperm-whales fight fiercely among themselves. The males battle with other males, and kill each other. Great toothed whales have been found dead with their mighty jaws fast locked together. They had fought to the death, and in their closing struggles had got their jaws so tightly locked that they could not be separated.

THE GREEDIEST BEAST THAT LIVES IN THE WATERS

The cannibal whale is the grampus, or "killer," as sailors call it. This is a toothed whale of a different type. It has teeth in both jaws, and is the greediest beast in the waters. One grampus has been known to swallow several seals one after another. Although the grampus attains a length of over 20 feet, it would be no match for

a sperm-whale in single combat, so several grampuses hunt together, like wolves. By weight of numbers, by their repeated attacks with their powerful jaws, they are able to tire out the biggest whale, and kill and eat it. They sometimes have powerful allies in the sawfish and the swordfish.

Though the names of these two creatures are similar, the fishes themselves are very different. The swordfish has a great spear growing out from its snout. The sawfish has, in the same place, a blade of the hardest bone, from both sides of which grow out horrid saw-like teeth. The swordfish darts with great violence upon its enemy, and stabs with its sword. The sawfish makes the same sort of rush, but it does not stab and draw out its weapon as the swordfish does. Instead, when it has thrust its cruel weapon into the soft part of its victim's body, it actually saws with it, tearing open a great wound, from which even the whale, lord of the waters, must die. Sometimes the swordfish and the sawfish join with grampuses in attacks upon the whale. The swordfish reaches a length of 20 feet; the sawfish grows to over 12 feet; so the poor whale, with such savage and powerful foes, has not much chance of life.

THE WONDERFUL STRENGTH A FISH CAN PUT INTO ITS SWORD

The strength of the swordfish is almost incredible, but here are two instances to show what it can do. One swordfish, mistaking a ship for a whale, rushed at it, and drove its weapon through the sheet of copper with which the hull of the vessel was covered, through a plank of oak 2½ inches thick, through a beam 7½ inches thick, and then through another plank of oak 2 inches thick. Even then it might not have stopped, but at this point the sword broke off.

Another swordfish, attacking a whaling-vessel, drove its spear through the copper and then through 17½ inches of the hardest oak, and finally through the timber of a barrel of oil. There the weapon remained fixed so tightly that not a drop of oil escaped from the barrel. These are the natural enemies that the poor whale has to face. He himself never attacks other large creatures, being the most harmless animal in the sea, unless he is enraged by enemies. In that case he is a terrible foe. With one blow of his awful tail he can shatter the side of a boat. He can send a small boat flying out of the water into the air, or, with a single snap of his jaws, can bite it to fragments.

It is a blessing that the angry whale does not live on land. The paddles with which he swims are his hands. He used to have hands exactly like ours, only larger—with four fingers and a thumb. The fingers and thumb are still there, but now they are covered over with skin and flesh to form a paddle or fin. Deep down in his flesh we also find remnants of the bones which, ages ago, formed his hind legs and feet. His ancestors must have lived on land.

THE SEA-UNICORN, OF THE WHALE FAMILY—THE PORPOISE

Porpoises and dolphins do not seem, at first sight, to resemble whales, but they are members of the toothed-whale family. The most curious of the family is the narwhal, also called the sea-unicorn, because it has a long horn of ivory growing out from its snout. This is not like the spear of the swordfish. When a baby the narwhal has two little tusks in the upper jaw. These never grow any bigger in the female, but in the male the left tusk grows to a great size. The right remains small, though it increases in hardness. The left becomes a rod of spiral ivory, from 8 to 10 feet in length. With this weapon the narwhal can do great damage to fishes and to boats. But it has no ordinary teeth, so it has to content itself with soft food like the cuttlefish.

A close relation to the narwhal is the white whale, or beluga, from the skin of which much of the so-called "porpoise-leather" is made. It is a valuable animal to the Eskimos, who eat its flesh and use its blubber for oil, use its skin for various purposes, and finally feed their dogs upon what they themselves cannot eat.

One of the commonest of sea-animals is the porpoise, a handsome, graceful animal, of which the largest are about 5 feet in length. It has more than 100 teeth, and its jaws lock together perfectly so that once it seizes a salmon, a herring, or a mackerel, there is little chance of the victim escaping. The porpoise has a tiny ear, and there remains a spot near it which shows that once it had an outer ear, like the eared seal. An interesting discovery about the porpoise is that it has on its back fin a number of horny knobs. These are the last remnants of the bony armor in which sea-monsters were clothed after they had ceased to wear a covering of hair. Porpoises are magnificent swimmers, and no fish can escape them.

THE LIVELIEST ANIMAL IN THE SEA, WITH OVER 100 TEETH

The dolphins are a little longer than the porpoises. They are different, too, about the head. The head of the porpoise is short. The dolphin

HARPOONING A PORPOISE FROM THE MARTINGALE STAY
OF A WHALER
From the painting by Clifford W. Ashley

has a beak like that of a great bird, but in it are more teeth than any other animal has—more than 120. Its food is like that of the porpoise, but it likes shell-fish as well as fast-swimming fish.

The dolphin is the liveliest animal in the sea. It assembles in herds of twenty or more, and leaps and tumbles and gambols in the waves as merrily as squirrels in the trees. Dolphins will follow ships for hundreds of miles, and there has never been a ship which the swift dolphin could not outpace. The porpoise has a voice, and cries loudly if in distress. So has the dolphin, but it uses its voice for calling to its companions. It is like the distant lowing of a cow.

It is not the lowing of dolphins which makes men believe that they hear and see mermaids at sea, neither is it the sight of dolphins which deceives them. The so-called mermaids are two sea-animals, the manatee and the dugong. Together they form one family, which are called *Sirenia,* a name given them from their fancied resemblance, in the face, to mermaids or sirens. To an ordinary person they look like a kind of porpoise. But they do not eat fish; they live on seaweed and water-plants. The manatee always lives in the shallow sea, but the dugong goes up rivers and eats the plants which grow in their beds.

Both these animals have round, black heads. When feeding their young they hold them in their arms, or flippers, so that the heads of the mother and baby are above the water. Sailors have seen them, and thought that they were mermaids. For thousands of years it was believed that there were mermaids and mermen, human creatures with the tails of fishes. When you see the manatee and the dugong you will wonder how people could have mistaken them for human beings.

HOW THE SEALS SUFFER THAT WE MAY WEAR BEAUTIFUL FUR

When you see a sealskin jacket perhaps you never think of the thousands of miles which that lovely fur has traveled in the depths of the ocean. If people realized what cruelty is practised in getting the fur, they would not wear it. The seal is one of the most wonderful creatures in the sea, and used at one time to approach boats and villages by the sea, as if it wished to be in the company of men. But because some kinds of seal have fur which men and women wear, and because others yield blubber for oil, and skins which make leather, men have hunted it so savagely and persistently, in spite of laws for its preservation, that the number of seals is rapidly being so reduced that in a short time there will be scarcely any left in a wild state.

The seal is an animal which lives the greater part of its life in the sea, but every now and then it goes on land, or rests upon floating ice, and it is then that men kill it. Each spring the old seals go to certain islands to rear their young. The old males go first, and the females and younger males follow. The elders fight savagely and long until all the families are collected.

When the babies are born they have to be taught to swim, for the young seal does not take naturally to the water. At first it seems to dislike it, but the wise mother gets it down to the waves, shows it how to swim, and makes it at home in its new element.

With the old seals have come seals born the year before or the year before that. Men are on the lookout for these. They drive them into the interior of the island, away from the others, and there knock them on the head with clubs, and skin them before they are really dead. These are not the only seals killed. The mothers and fathers of the baby seals, and even the little ones, are slain. It is a cruel and horrible trade, that of the seal-hunter, and makes people who know ashamed that such things should happen. Of course, some seal-hunting would have to be done, for if seals were too numerous they would destroy too many fishes in the waters where men fish for human food. But where the baby seals are reared, and away from men's fishing-grounds, there is plenty of room as well as plenty of food for seals.

There are many kinds of seals. One, called the hooded seal, has a sac over its nose, which, when the seal is excited, it can inflate. Another, called the harp-seal, has a figure like a harp marked upon its sides. The leopard-seal is beautifully marked like a leopard. The common seal does not give the precious fur, but it has valuable oil, and its skin makes leather.

THE HUGE ELEPHANT THAT PARADES THE WATERS

A relative of the hooded seal is the sea-elephant. This is a giant, and doubly deserves its name. It measures, when fully grown, from 20 to 30 feet in length, and from 15 to 18 feet round. Thus it is actually bigger than our land-elephant. It has a long snout like the trunk of an elephant. When on land it walks awkwardly on its four feet, or flippers. The common seal has its hind legs turned backward, and uses them only for swimming. It does not walk, but

has to jerk itself along by a series of shuffles, and for this purpose it has very strong muscles in its body.

The seal which bears the fur is called the sea-bear. It is nearly allied to the sea-lion, but the sea-lion has only long hair, not fur. The sea-bear has long hair, but underneath is the beautiful fur which keeps it warm. All seals are fine swimmers. Ships follow and hunt them in certain parts of the year, sending off boats from which men shoot or spear them. But when the time comes for the seals to go to the land, they increase their pace, and swim with such swiftness that no ship can keep up with them. After that, other men follow them to the land.

The sea-lions have their hind legs turned forward, so that they can get about fairly well on land. They can climb, too.

Sometimes they are found upon icebergs, high up on the ice, and sailors wonder how they can have jumped so high. They have great leaping power. What a sea-lion can do was once shown at the London Zoo. On the day of its arrival it was put in a pond, around which was a railing 3 feet high.

In the morning it was found that the sea-lion had left his pond, climbed over the railing into another pond, out over the railing of that pond, and then into the pond where the swans were. Whether he would have killed the swans or not, we cannot say—he was not hungry at the time. But seals will eat birds. Sometimes they snap up sea-gulls, and they often eat penguins. In the stomach of seals are often found a number of stones, and some naturalists believe that those stones have first been swallowed by the penguins which the seals have eaten.

SEALS RUSH TO THE SHORE ALTHOUGH THEY FIND NO FOOD THERE

If you have ever seen seals or sea-lions you know what a noise they make when feeding-time is near. They have a sort of hoarse bark when full-grown; the babies "baa" like lambs. No other animal has a better brain than the seal. They love music. The sound of music in a seaside village will, it is said, often draw them to the shore.

The seals are like the camels and the whales—they can close their nostrils tightly, and keep out anything which they wish to exclude. This is necessary for them when in the water. They can remain below the surface without breathing for a long time. Another curious thing about them is that, though they get enormously fat when in the water and feeding regularly, they can go without food for three months at a time. For a quarter of a year they remain on land while their families are growing up, and in all that time they never go to the sea for food. They fast for three months without a break, and go back to the sea as lean as skeletons.

THE WALRUS, A SEA-GIANT WITH TUSKS OF PURE IVORY

The walrus is included among the seals, though it really is not a seal. Its body is in most respects like the body of an elephant-seal. It grows to a huge size, being from 12 to 15 feet long, and very heavy. It can walk, in an awkward, waddling way, on land. Its most remarkable feature is a pair of enormous tusks which grow downward from its upper jaws, like the tusks of the extinct saber-toothed tiger. These are of the purest ivory, and measure fully 24 inches from the point at which they emerge from the gum. Although he is such a monster, the walrus is one of the least destructive of all the sea animals. Its mighty tusks serve to grub up shell-fish, shrimps, and other little things which live at the bottom of the sea where he makes his home. The shell-fish he cracks with his teeth; he puts out the broken shell, and with his tongue draws out that part which he wishes to eat. The tusks are said to help him to climb on the ice, and on rocky islands to which the walrus retires to rest.

THE GREAT LOVE OF THE WALRUS FOR ITS LITTLE ONES

If he can, he will always take to the sea when attacked; but should he have to fight, he can inflict frightful injuries with his tusks.

He is hunted for his blubber and skin as well as for his bristles. The walrus and all the seals have strong bristles about their mouths. These may act as feelers, as the cat's whiskers do; but it is supposed that they serve the same purpose as the whalebone in dredging and screening the shell-fish which the creatures seek for food. Seals and walruses are devoted to their little ones. The male walruses will give their lives for their babies. Hunters kill the mothers and babies first, because they know that the male walrus will stay and fight to the last.

WHAT I FOUND ON A PIECE OF SEAWEED

BY EDMUND WILSON

You all remember having read in your histories about the first voyage of Columbus, and have not forgotten that when the three little vessels were only half-way across the broad expanse of the Atlantic, they sailed through great masses of floating seaweed. The sailors thought these seaweeds must have been torn by the waves from some neighboring coast, and therefore believed their voyage was nearly ended. But, as they sailed onward, anxiously straining their eyes to catch the first glimpse of land, all the seaweed was left far behind; and it was not until many long days had passed that the distant line where the sky and water met was broken by the shore of the New World.

Now, the naturalists who study seaweeds have given the name *Sargassum* to the kind that misled Columbus. They have found that the *Sargassum* (which is also called gulfweed) probably does not need to grow fast to the shore like the common seaweeds you have seen at the seaside in summer, but has little round air-bladders, or floats, which buoy it up so that it seems able to grow and flourish at the surface of the sea, even many hundreds of miles from land. Vessels in the very middle of the Atlantic Ocean often sail for days through the floating meadows formed by this curious plant, and sometimes even powerful ships have hard work to push their way through.

One calm September day, I was cruising about in a little steamboat, off the southern coast of the United States. The sky was cloudless, and the bright sunlight streaming down into the clear water enabled us to see far below the surface.

We could see great jellyfishes lazily flapping along; and now and then a shark would dart by, making the small fishes scatter in every direction as he passed. Presently we saw masses of this gulfweed floating about us, and seizing a long-handled net, I fished up a piece as we steamed along.

I suppose many people would have thrown it away as a useless piece of weed; but we knew better than that; for, when we came to examine it carefully, we found that the *Sargassum* was the home of a number of strange creatures which were so curious and interesting that I must tell you something of them. Here is a picture of the *Sargassum* just as it looked after being fished up, and put into a big glass jar full of pure sea-water.

The round knobs on the stem are the air-bladders, which keep the plant afloat so that it rises and falls with the waves, and drifts along on the tides and currents. Perhaps this piece had drifted hundreds of miles, for the Gulf Stream,

THE SARGASSUM.

which flows northward like a mighty river from Florida and the West Indies, may have borne it onward for many weeks.

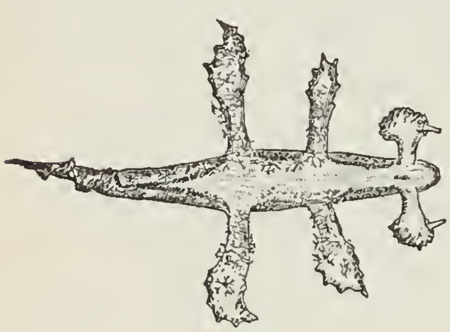
Our seaweed may therefore have been a great traveler, and may have had some strange adventures on its way. We may be sure it has weathered some great storms, and has been well tossed and shaken about by the big waves. The white gulls have wheeled about in the air above it, or even brushed it with their wings as they paddled along beside it. Perhaps some savage

shark has given it a slap with his huge tail, as he darted by in pursuit of his prey.

Could the *Sargassum* speak, it might tell us whether there really is a sea-serpent or not! But it tells no tales; it floats there in the jar very quietly and unconcernedly, and so we must see what we can find out from it for ourselves. If you look closely at the picture, you will see some very odd things indeed. After we had fished up the *Sargassum*, one of my friends was watching it in the jar. Suddenly she exclaimed, "Why, the seaweed is *alive!* It is moving its leaves."

We could hardly believe our eyes, and yet some of the leaves certainly were waving to and fro, though the water in the jar was perfectly quiet. What could it mean? All at once we became aware that there, crawling on the plant, were two large sea-slugs, which had entirely escaped our notice. And the curious part of it is that their bodies were of exactly the same color as the stem of the *Sargassum;* and that each one had growing from its body three pairs of things shaped and colored precisely like the leaves of seaweed, but really parts of the animal. These were the "moving leaves" which had excited our wonder. To make the illusion more perfect, the leaf-shaped appendages were covered with little, branching, tufted outgrowths, closely resembling something growing on the real leaves of the plant, about which I shall tell you presently.

Here is a picture of one of these curious animals when separated from the seaweed. It is really very similar to a snail without any shell, or like one of the slugs you may have seen on damp, decaying wood, or upon apples lying beneath the trees in the garden—only, the imitation leaves disguise its real character. The pointed end is the tail, and the other end is the head. The front pair of false leaves are short and blunt, and look very much like some of the dead or imperfect leaves of the plant. The conical structures on the front sides of them are feelers, or tentacles, of which the sea-slug has great need, for it has no eyes and must guide itself in another way.



A SEA-SLUG.

The two sea-slugs are easily seen in the illustration, because they are not colored. But I can hardly tell you how perfectly they resembled the seaweed when alive. Their bodies were a beautiful, reddish-brown color, exactly like the stem of the *Sargassum,* speckled with pure white and dark brown, imitating the spots and patches on the latter. The imitation leaves were olive-green, precisely like the real ones, with a few darker blotches to imitate the stains and decayed spots. Altogether, you can hardly help fancying that the sea-slug has dressed himself up in the seaweed's clothes and is playing a sort of masquerade.

A LITTLE CRAB FOUND ON THE SARGASSUM.

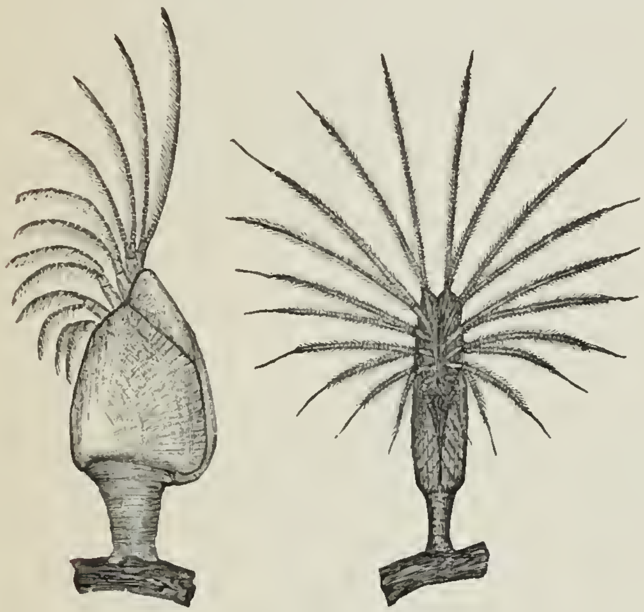
But the sea-slug has been disguised as a plant for a good reason. For the sea is full of hungry fishes, always roving about on the lookout for just such a titbit as a sea-slug. The sea-slug therefore has been colored and shaped like the seaweed it lives on, in order that, when some sharp-eyed fish comes swimming along, he may never dream so tempting a morsel to be near. I suppose he looks at it and turns up his nose, saying to himself, "Pooh! that 's nothing but an old seaweed!" and off he goes, while our sea-slug no doubt laughs in its sleeve and says, "Seaweed, indeed!"

This wonderful resemblance is an example of what naturalists call "protective resemblance," which in this case is so perfect as to merit the name of "mimicry." Because, you see, the animal *mimics* the plant, and is thus *protected* from its enemies.

Now, let us see what else we can find on the *Sargassum*. In the first place, you see a queer little crab on one of the leaves. He is such a little fellow that we must magnify him a great deal to see just what he is like.

Here he is as he looked under my magnifying-glass. He has two huge black eyes, with which he keeps a good lookout, and at the least alarm he whisks around to the other side of the leaf in a twinkling, just as a woodpecker dodges behind a tree. When alive he was beautifully marked with red and black, and so transparent that you could look into his body and see that his heart was beating and his stomach digesting his last meal.

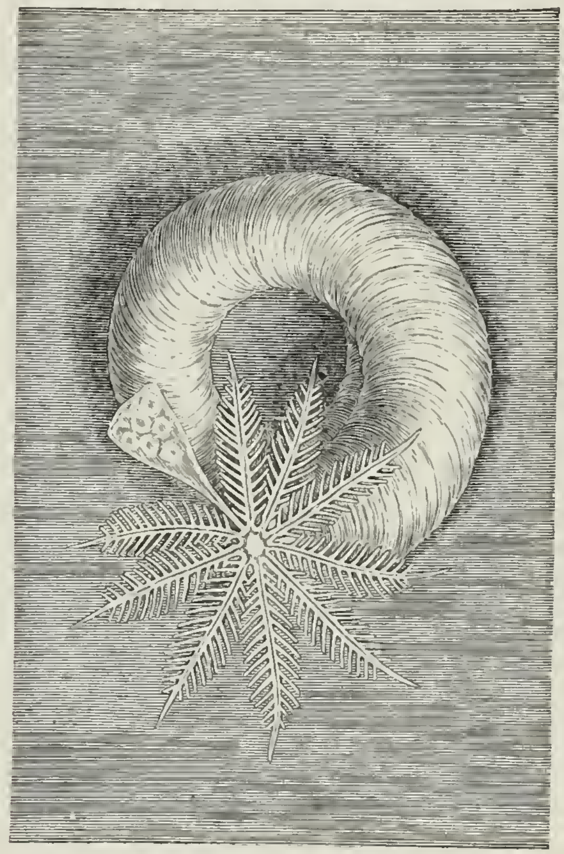
A little higher up, two barnacles are grown fast to the stem, with their arms spread out in the water. You can see them better in the two separate pictures, one of which shows the barnacle from the side and the other from in front. What does he do with the long, hairy arms? If we watch him for a few moments, we see the arms suddenly pulled entirely in—they shut up just as you close your hand by folding your fingers together. In another instant the arms are put forth again, and make a grasping or clutch-



SIDE VIEW. FRONT VIEW.
BARNACLES.

ing movement in the water, after which they are again withdrawn. So the barnacle goes on, continually grasping in the water, and, of course, you have guessed what he is doing. Yes, he is fishing—he is trying to make a meal of the microscopic creatures which are swimming about in the water. You see, the barnacle is grown fast at one end to the seaweed, so that he cannot swim about in pursuit of his tiny prey. He must wait for the unlucky little fellows to come within his reach. And as he is stone-blind, having no eyes, he cannot keep watch, so as to throw his net at just the right moment; he has to keep grasping away at haphazard, and be content if he makes a catch only now and then. But woe betide the little shrimp or worm that is unwary enough to come within reach! The long arms instantly close on it; it is dragged down into the terrible jaws, torn to pieces, and eaten. And then the lucky fisherman begins to throw his deadly net again.

Now look carefully at the picture, and you will see two or three little star-shaped objects attached to some of the leaves. If we magnify one of these, here is what we see. There is a little coiled tube, as hard as stone, within which lives a little worm, which the naturalists call *Spirorbis*. When he puts out his head he spreads out in the water a star-shaped circlet of feathery arms, which looks very much like a delicate flower. A very dangerous flower it is, though, this pretty star of feathers, for it is another fishing-net like that of the barnacle—only, the feathers are held quite still, and move only when the animal is alarmed or when they close upon some unlucky little creature which ventures too near. If the *Spirorbis* is alarmed, he instantly pulls in his head with its fishing-net, and when he goes into the tube he securely corks up the opening with a kind of stopper or plug, which he pulls in after him. You can see the stopper in the picture, occupying a position opposite to one of the arms.



THE SPIRORBIS.

A curious fact is, that the stopper is hollow, and in this cavity the mother *Spirorbis* carries her eggs until the young ones are hatched. The eggs are shown in the figure as little round balls.

Are you getting tired of the seaweed? Well, I will tell you of just one more thing, and then we will leave it. You will see little dark patches on some of the leaves. In the real seaweed these patches look like small tufts of moss. But these moss-like growths are really colonies of microscopic animals, which have been called *Bryozoa*, the zoölogical name for "moss-animals." Under

the microscope we see a most curious sight, which I have tried to show you in this drawing. Each one of the tiny specks has become a flower-like creature, looking not very unlike a dandelion or field-daisy. But you would think them very wide-awake flowers, for they are all swaying back and forth, moving the arms about in the water, and every now and then one of them disappears in a twinkling. In its place is left an oval opening; and, if you watch carefully, the flower gradually and cautiously comes forth from the opening again, and spreads out in the water its graceful crown of arms.

You see, each moss-animal has a little stony house, or cell, in which it lives, and from the mouth of which it can spread out a flower-like fishing-net, not so very unlike that of the *Spirorbis*. All these cells are so joined together, that they form a kind of coral, somewhat like that of real coral - animals which make the vast coral-reefs or coral-islands. The fishing-net is interesting in its structure. Every slender arm is covered with little vibrating hairs or paddles (too small to see in the drawing), which are constantly waving to and fro when the arms are spread out. All the paddles move together, and in such a way that a little whirlpool is made in the water around each animal, and the bottom of the whirlpool leads right into the creature's mouth, which is in the middle of the flower.

"MOSS-ANIMALS."

You have read the stories (which you must not be too ready to believe, though) of the great Maelstrom, or whirlpool, off the Norway coast, into which boats and men are said to be drawn, and after circling round and round, faster and faster, and ever approaching the middle, are at length sucked in and swallowed up by the mighty waves. Well, the whirlpool about each moss-animal is equally terrible, in its way, to the little creatures swimming in the water; for if they once come within reach there is no escape—they are sucked in and swallowed *alive* before you could say, "Jack Robinson." And here I must tell you something curious. The bodies of all the moss-animals are joined together, so that whatever each one eats benefits all the rest, and there can be no quarreling among them over their dinners.

The little feathery tufts on the lower leaves are animals, too, and are called hydroids; and, under the microscope, they much resemble the moss-animals. Like them they have separate heads and mouths, but their bodies, and even their stomachs, are all joined together.

HYDROIDS.

Besides the sea-slugs, crabs, barnacles, spirorbes, bryozoa, and hydroids, many other little creatures grew fast to the seaweed. But I must not try to tell you about these, for very likely you have had quite enough seaweed for one time.

It is a curious thought that there are countless thousands of these seaweeds in mid-ocean, drifting about at the surface of the sea, every one the home of a little society more or less like the one I have told you about.

A poet once said:

> "There's never a leaf nor a blade too mean
> To be some happy creature's palace."

And no doubt our little crabs and barnacles, with their queer traveling companions, are quite happy and well content in their floating home, though a thousand miles from land and buffeted about by winds and waves.


"FROM GREENLAND'S ICY MOUNTAINS."

ICEBERGS

BY DAY ALLEN WILLEY

"From Greenland's Icy Mountains" is the beginning of a hymn which most of us have sung many a time in church or Sunday-school; but the reader may not know that often these mountains are actually floating on the waters of the sea, for most of the icebergs come from this land far up in the northern ocean—so near the North Pole that nearly all of its surface is covered with ice which formed, no one knows how many ages ago.

Had the geographer given the name Iceland to this great region of the arctic, it would have been far more suitable, perhaps, than Greenland, for its smaller companion which lies between it and the continent of Europe has more vegetation; but when Iceland was first settled, its glaciers and snow-fields probably caused the hardy Danes who took possession of it to think this was the most fitting title, though its masses seem small compared with those of Greenland, for here the earth's surface is buried in an ice cap which the scientists believe to be fully 3000 feet—over a half mile—thick in the interior. From this cap extend numberless glaciers, which reach clear to the waters of the ocean, sometimes far into the sea.

We might call Greenland the world's ice-box. If you glance at the map, you will see that the State of New York, large as it seems to us, is not over one twentieth of the size of Greenland: for New York contains only 47,000 square miles. Then think that the glaciers are steadily moving away from the center of Greenland, really being crowded off the land, and it will not seem so strange that here is the birthplace of nearly all of the icebergs that are so feared by the mariner.


A CURIOUS FORMATION OF AN ICEBERG, CAUSED BY MELTING.

The manner in which the iceberg is formed is worth the telling. Physical geography explains

ROWING IN FROM AN ICEBERG.

how the glaciers work their way along the valleys in the earth's surface. As the interior of Greenland is much higher than the coast, many of them lie on slopes which of course incline toward the sea. The enormous weight of the ice mass forces it over the surface, even where the incline may be very slight. For many miles the shore rises abruptly from the ocean in steep walls of rock against which the waves dash. The glacier reaches the edge of the bluff and then is pushed over

A FLOATING "MOUNTAIN" FROM GREENLAND.

it. Perhaps it hangs above the sea for a distance of fifty feet or more, because if the ice is very thick it has enormous strength, but finally the force of gravity conquers, the edge of the glacier breaks off and topples into the sea, and thus an iceberg is launched.

There are other places where the shore rises gently or where valleys extend downward to the ocean. The ice moves along these depressions and far out into the water, until it may extend miles beyond the actual shore-line. But underneath may flow one of those odd rivers of the ocean which are called the arctic currents. Possibly a storm has occurred far out on the open sea which hurls its waves against the glittering mass, or stirs the depths beneath. These may rend the glacier apart or, possibly, on one of those occasional days of the short Greenland summer when the sun's rays are warm enough, they weaken a portion which is thinner than the rest. So other bergs are formed to be caught in the ocean river and perhaps carried five hundred miles north from their starting-point until, drifting into the Labrador current, they float southward on the voyage from which none returns.

So if you are crossing the Atlantic and chance to see an iceberg glittering in the sunlight, you may think of it as a part of a glacier that is per-

haps a thousand years old. Well may it cause awe as well as admiration. Viewed from the ship's deck it seems a hundred feet or more in height, but the cautious captain usually steers a course that is some distance from the berg, for he does not know how much of it may be hidden below the surface. If you guess its top to be two hundred feet above the surface of the sea, you may not be far wrong. Some have drifted past the city of St. Johns, Newfoundland, that were nearly as high as the hills that mark the entrance to its harbor, and icebergs rising two hundred and two hundred and fifty feet out of the ocean are not uncommon; but the captain has good reason to be cautious, for the mass that looms up so stately is but a small portion of the entire berg. If it is two hundred or three hundred feet high, it may reach a thousand feet below the level of the sea. If it is very high in proportion to its length and thickness as seen above the water, it must be enough submerged to keep it from toppling over, for, as is well known, ice contains so much air that it is very buoyant, therefore the part submerged acts like the ballast in a ship. It helps to keep it upright. The part which is hidden may project sideways or lengthways from the portion which is visible, and if the vessel ventures too near, she may strike the projection and be sunk, or "grounded" on the berg. This strange accident has happened more than once in the North Atlantic ocean. Sometimes a berg is grounded itself. Floating southward with the current, it may be carried into a part of the sea where its bottom strikes the ocean "floor"—the bottom of the sea. There it is held perhaps for months, until the melting of the upper part causes it to rise sufficiently to clear the ocean bed, but it may be disengaged by the waves of a storm which heave it from its resting-place.

A SCHOONER AMONG THE "GROWLERS," AS THE SMALL ICEBERGS ARE CALLED.

As we see them at a distance, these ice mountains from Greenland's coast are very picturesque, especially when their sides reflect the rays of the sun. The ice may not seem as clear and as pure when you come close up to it, but seen a half mile or a mile away it is a sight to be remembered by the one who has never before witnessed it. In shape it may seem like a mountain—slopes and summit being perfectly outlined. Fancy may shape another into a cathedral from which glittering spires arise. Another looks like a vast block of

granite or marble just after it has been taken from the quarry. Seen from another point, it may bring to mind a crouching animal, such as a lion or a dog or a walrus. Nature molds the masses with the aid of the wind and sun.

As they get further and further southward, the warmer air rounds off the sharp corners and makes curves of beauty. They do not look so rough and jagged as when they begin their journey, but this glacial ice is much harder than that which forms on the surface of the sea or lake.

"LIKE SOME GIANT ANIMAL."

Constant pressure upon it as the glacier has been crowding its way to the sea, has made it dense, compact, just as hammering and pressing make the iron bar harder and stronger.

But on looking at the iceberg through the marine glass or telescope, its walls may appear dark. Perhaps you see black objects in them. These are parts of Greenland which it has carried away, either to drop into the sea as it melts, or deposit on the shore, if it should be stranded, and there dissolve. As the glacier moves seaward at the rate of an inch or a foot a day, it really pushes through the earth and softer rock, carrying this sediment along, the mixture being what is called the moraine. The dirt and stone sink into the interior of the ice mass. So some of the larger glaciers reaching that arm of the ocean known as Melville Bay, have brought to it boulders weighing a ton or more, and when overlapping edges of glaciers have split off and fallen into the water, these boulders are often held in their embrace. It is a curious fact that many huge stones found on the coast of Labrador and Newfoundland have been carried to their final resting-place all the way from Greenland imbedded in icebergs that stranded or grounded on these shores.

Melville Bay, Greenland, named after Admiral Melville, the celebrated arctic explorer, is almost surrounded by glaciers, some of which reach back into the interior a distance of twenty-five miles; but there are a number of bays or what the Norwegian would call fjords also on the west coast that pierce the land for fifty miles, and many icebergs come from them as well. The bergs which go around Cape Race and pass Newfoundland have been partly melted by the warm, moist winds which blow from the southeast against their sides. In spite of their dimensions, most of them are small compared with the enormous masses that float out of Melville Bay and the other inlets. Arctic explorers have seen some which were fully five hundred feet high and several miles around at the point where they rested in the water—actually ice islands in size.

When an iceberg breaks away from a glacier, it sounds like the report of a heavy gun, and may be heard for miles, while its fall into the water produces waves which roll from shore to shore of the bay. The sound caused by the breaking of

the ice in one place frequently causes other ledges to break off. It is supposed that the vibration of the air due to the sound waves produces this effect, just as an avalanche of snow is sometimes started down a mountain merely by a shout or the ordinary tone of the voice.

It is a long voyage which the bergs make before they disappear to mingle with the waters of the Atlantic. Nearly all of the year they are floating away from Greenland's western shores, first taking a course which carries them as far north as the 75th parallel of latitude. Glance at the map and you will see that this is near the great source of the bergs,—Melville Bay. Then they swing westward and, coming down the mainland of North America, skirt the bleak, bare shores of Baffin Land and Labrador, sometimes blocking up the straits of Belle Isle that divide the Labrador peninsula from Newfoundland. In the late summer and early autumn, the stately procession of icebergs can be seen to the best advantage from the shores of England's oldest colony. Some days only one or two may come in sight. On others a half dozen or more may be visible at one time. To study their massive walls it would seem as if they defied Nature to melt them,

RESEMBLING A BLOCK OF HEWN MARBLE.

but when they get as far south as Newfoundland, they decrease more and more rapidly in size, finally becoming "baby" icebergs, twenty or thirty feet in height, which frequently drift into harbors or continuing southward, finally disappear in the ocean. Their graveyard seems to be in the Atlantic about four hundred miles south of Nova Scotia. Here the water is of such a temperature

A VERITABLE ICE-MOUNTAIN.

that they melt below as well as above the surface. The sailor dreads these glacial islands, not only because his craft may strike one and be

THE SKELETON OF AN ICEBERG.

sunk, but because they change in size and shape far more rapidly than one could imagine. A berg which appears to be as solid as a mountain may become top-heavy and fall into the sea, crushing anything that is near it. Sometimes a venturesome fisherman will attach his boat to an iceberg by means of a rope if there is no wind, and let it tow him southward toward the fishing-banks, but he is taking a great risk in doing so. The smaller bergs, however, afford a supply of fresh, pure water, for the glacial ice is not salt. So when the skipper chances to be "short" of water it is a common thing for him to steer for the nearest iceberg and send a boat and crew alongside of it. The boat is moored to its side and the men cut off chunks which are taken to the vessel and melted down in a steam boiler. Where water is scarce in the coast towns the "baby" bergs are used for a supply.

Packs of ice a hundred miles wide are sometimes broken off from the mainland. The pack looks like a country of perpetual winter, as its surface contains more or less snow and is furrowed and ridged where the cakes have been driven upon each other and piled into heaps, by the arctic storms that break up the pack, only to again be frozen together. On the edge of the pack are numerous hummocks or piles twenty and thirty feet high. Often they become separated and the novice calls them icebergs, but they are not, because the berg is composed only of glacier ice, as we have stated. These hummocks are very dangerous, however, and many a craft has gone to the bottom of the sea by striking one of them. Sometimes pieces of the pack are separated from it, forming sharp-edged cakes which are mostly under water. These "growlers," as the seaman calls them, when tossed about on the waves are as much to be feared as the icebergs themselves, for they are so heavy that they deal a hard blow when dashed against the ship's sides, and their sharp, jagged sides will cut through the stoutest timber, even the copper which may sheathe the outside of the craft. Steamship passengers often like to see icebergs; but to the captains and navigators they are never a welcome sight.

IMPRISONED IN AN ICEBERG

BY C. F. HOLDER

"Sail ahoy!" came a shrill hail from the foretop of the trim bark "Laughing Polly," as it bowled along in the latitude and near vicinity of the South Shetland Islands.

"Where away?" answered a tall man with a tremendous voice, who was pacing up and down the quarter-deck, muffled in a great pea-jacket.

"Dead ahead!" came the voice of the lookout, who was the captain's son. He had taken the watch so as to be the first to sight land after the long run to the south.

The captain swung himself into the rigging, gave a glance at the supposed vessel, and then dropped to the deck again with a loud laugh. "Your ship is an iceberg," he called out. "A pretty sailor-man you are," he added, "not to tell an iceberg from a whaler."

"I can see her spars," shouted back the boy, who would not acknowledge his mistake; and indeed the nearer they approached, the more the object appeared like a vessel on the same course as themselves. It seemed a veritable ship, careening slightly in the brisk breeze. There were the white top-sails, with the shadows on them distinctly visible, and Ned—for that was our lookout's name—almost thought he made out a pennant at her mizzen-peak. So remarkable was the sight that the sailors all gathered in a group forward, and watched the strange sail. But on getting within a mile of it, they plainly discerned that it was an iceberg of enormous dimensions, and which, even at that distance, seemed to tower above them. Its resemblance to a ship was quickly lost, and it loomed up, a great mountain of blue ice, momentarily changing its shape and color.

The captain had just given orders to shift the course of the vessel, when a cry of astonishment rose from the crew, who were still watching the distant berg. The captain and mate rushed forward, and saw the cause of the excitement. The ice-mountain had changed its position, and instead of being upright was heeling over. Faster it moved, until finally, fairly overbalanced, it fell over in the water with a mighty crash, hurling into the air great waves three times as high as their masthead, and sending out huge rollers on either side, while vast blocks of ice seemed to break off and float away.

"It 's gone," shouted Ned, excitedly.

"No, it is n't," said his father. "Just keep your eyes on it."

The words were hardly spoken by the captain before a still more remarkable phenomenon occurred; the iceberg appeared gradually rising from the sea, slowly resuming its original shape, like an island of ice being forced above the surface by some invisible power. Slowly but perceptibly it rose, until finally the astonished sailors saw the gigantic berg, almost as large as before, rocking and oscillating, again upright upon the surface.

In the meantime a series of waves from the scene of action had reached them, and Ned was nearly thrown from the foretopgallant-top, where he was still clinging. The ship pitched so violently that it seemed almost as if they had experienced a series of tidal waves.

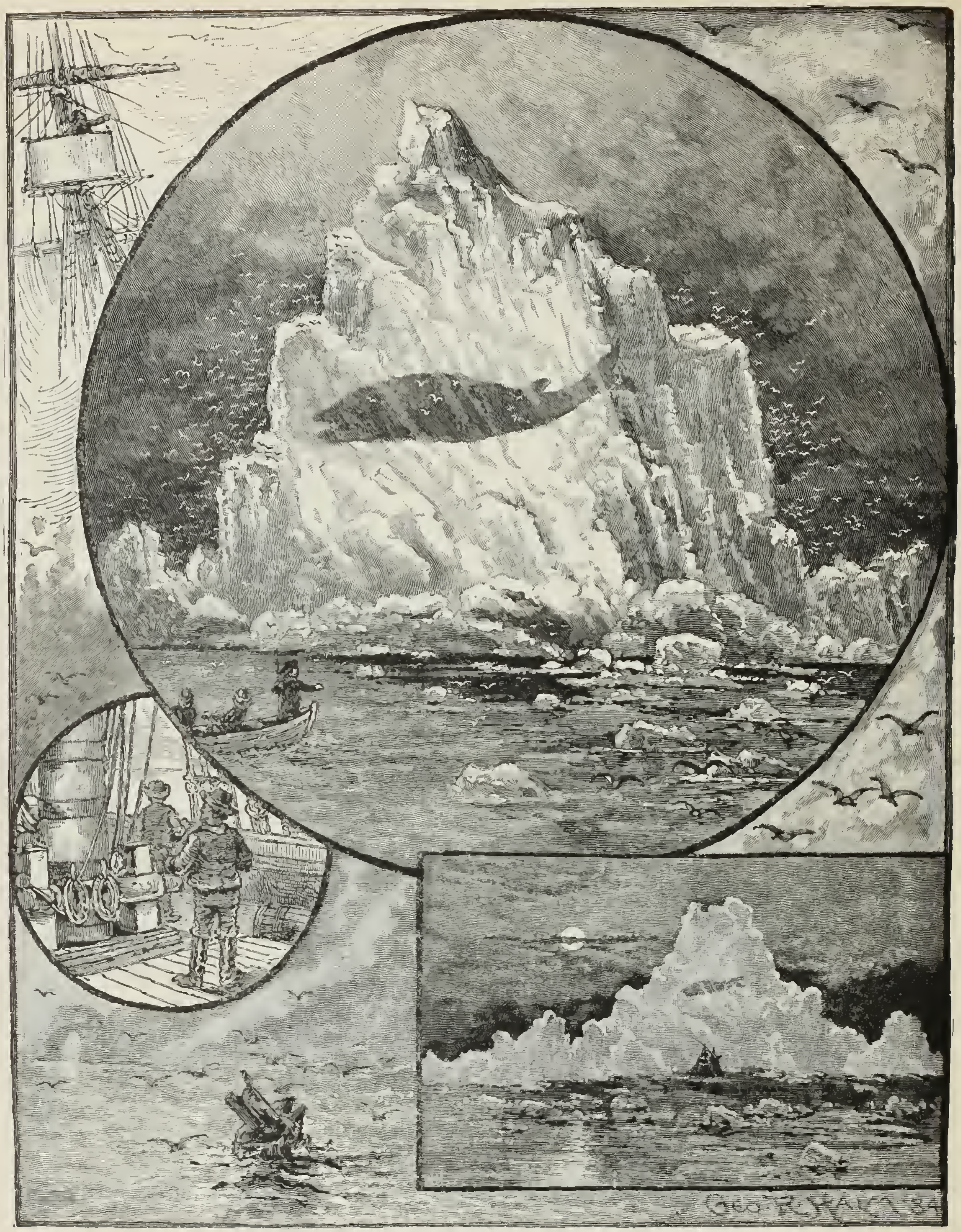
"It 's only an upset," said the captain, as Ned rejoined him on deck. "You see, one of these great bergs floats about until it gets top-heavy, which is occasioned by the lower portion, a thousand or fifteen hundred feet below, striking, perhaps, a warm current that melts it away, until finally the exposed portion overbalances the base, and over it goes with a thundering crash, as we have seen."

"I had no idea a berg as large as that could tip over," said the young sailor.

"I have seen larger ones than that roll," replied the captain. "There seems to be no limit to their size. An iceberg was observed some years ago, not four hundred miles from here, that was two and a half miles long, over two miles broad, and a hundred and fifty feet high, and it must have weighed fifteen hundred million tons. Yet that was by no means a large one. I have seen them off Cape Horn nearly eight hundred feet high; and a mass of icebergs was once seen sixty miles long by forty broad, and three hundred feet high. As only one-tenth of the whole mass rises above the water, the higher out of water, the larger they are, and one which exposes two hundred feet would probably have eighteen hundred feet under water."

The conversation was here interrupted by a hail always welcome on a whaler. Whether it was "There she blows!" or "Whale o'!" they could not make out; but seeing the lookout pointing toward the floating island, they turned that way.

The vessel had suddenly passed a projection of the berg that showed them its broad side and snowy peak looming three hundred feet into the



THE WHALE WITHIN THE ICEBERG.

air, and near the top, frozen in the icy block, was the black body of an immense whale.

"Never mind the boats," said the captain, recovering from his astonishment, and recalling an order which he had given upon hearing the hail. "Well, that beats all my experience in thirty years' whaling," he continued. "A finback in an iceberg!"

"A frozen whale in command of a ship of ice," said Ned. "And to think that we saw it rise three hundred feet from the water!"

"It 's the greatest leap on record," exclaimed

his father, "and as such jumps don't occur every day, we may as well have a nearer view"; and, instructing the helmsman, the whaler was hauled a point or so on the wind. It was soon found, however, that a nearer view of the whale would involve being becalmed in the lee of the berg, so the boat was lowered, and the captain and Ned were soon being pulled toward the huge prisoner of the ice-island.

As they approached, the sight became still more remarkable and impressive. The sight was very tantalizing to the whalers, as there above their reach was the game they were in search of; but it was out of their power to dislodge it from its bed of ice, and they reluctantly rowed back under the shadow of the berg. Looking up at the imprisoned whale, they saw that it was a rorqual nearly one hundred feet in length—the largest of living animals.

As the wind had died down, they could not leave, and so they witnessed the effect of sunset on the ice-island. The tall peak was flooded with golden lights; dark shadows crept up its sides, gradually changing the golden radiance to gleaming silver, then to gray, which was in turn lost in the approaching gloom. But soon the moon appeared, bathing the berg with its silvery light and bringing out with startling distinctness the frozen giant.

Late into the night the sailors watched the island of ice, fearing that perhaps the surface current might bring them dangerously near it, but finally the wind sprang up, the sails filled, and the frozen whale was soon lost in the distance.

Upon the return of the whaler, two years later, the story was told, and it was found that several sea-captains had observed similar sights. One had seen a polar bear so imprisoned, while others told of enormous rocks and boulders that the bergs lifted from the sea. The presence of the whale in the berg was explained in a remarkable way. The huge animal was not entombed at sea, but it had been washed up on the thick ice-sheet in the lee of some antarctic island (these sheets sometimes extend many miles from shore); the snow from the shore had blown over it year after year, melting and freezing, until finally it was surrounded by hard, clear ice; the weight, ever increasing, forced the sheet under water, and as the snow was continually piling up on the top and changing to ice, the great mass with the imprisoned whale finally projected far out under the sea. The snow continued still melting and freezing, but piling upward. And then its weight, or perhaps a heavy gale, detached the mass from the field, and it floated away, an island of ice, bearing the captured whale beneath the sea.

As we have seen, the warmer currents wore away the submerged portion until the berg became top-heavy and overturned, bringing the long-imprisoned monster high up in air.

Sometimes, instead of being frozen in and carried to sea, whales are forced far inland. Captain Pendleton, who accompanied one of the United States expeditions to the Antarctic Sea, saw a whale two hundred and eighty feet from the surface of the water, in an ice-cliff eight hundred feet high. Whales and their skeletons have not only been found above the level of the sea at South Shetland, but a mile and a half inland away from the shore—wonderful examples of the power of frozen snow and water.

WATERSPOUTS AT SEA

BY J. O. DAVIDSON

HO has not noticed, during a sultry summer afternoon, the little whirlwind in the middle of the dusty road, caused by two breezes coming down streets that come together? First there will be seen a column of light dust revolving upward; next, moving here and there, it picks up stray bits of paper and leaves; then, as its whirling grows stronger and covers more ground, it adds to its strange collection of objects small sticks and tufts of grass; at last away it goes, whirling and dancing its elfin waltz until some immovable object interferes with its freedom of movement, when, like a spoiled child, it ceases its wild play, the whirling stops, and—pouf!—down come the sticks and leaves and paper, and the whirlwind is gone. In the Western States the same kind of whirlwinds grow to such proportions that through the thickest woods great tracks are mown as if cut by a giant scythe. But these big storms very appropriately receive the more dignified name of tornadoes.

On the ocean, these whirlwinds or tornadoes have, of course, no dust or trees to toss about in their giant hands, so they seize upon and suck up the water as the only plaything they can find, and, twisting it into a long glittering rope of trembling liquid, lift it up to the clouds, whence it is soon dispersed again in the form of rain. When performing such antics as these, the whirlwind or tornado is known as a waterspout.

The ship's crew which has so patiently steered its craft by treacherous rocks, over dangerous shoals, and through all kinds of storm and stress at sea, is often confronted by a new and unexpected danger—the waterspout. It most often makes its appearance beneath a black and lowering sky; but sometimes they start up mysteriously in clear weather to move along the ocean's rim in queer fantastic attitudes, looking for all the world like captive balloons dancing up and down, and tugging at their ropes—now near the sea, now near the sky.

"THE BROKEN COLUMNS OF WATER DROPPED IN TONS ON THE FORWARD DECK."

In the Strait of Malacca, and among the many islands in the China Sea, they are greatly dreaded by the peaceful fishermen, who must often pull up anchor and race for the shore to avoid the unwelcome approach of these giddy visitors, who fly hither and yon at their own sweet will, minus rudder or pilot. I have seen a waterspout make for a large fleet of rice-junks, and the scattering of the queer-looking craft under their brown sails and dashing sweeps looked comically like the flight of a flock of startled quail.

Sometimes a spout can be broken by the firing of a cannon close by; and then the singular spectacle will often be presented of the upper half of it going up into the clouds, while the lower part subsides into the sea. As most Chinese junks carry a number of guns and gongs, the waterspout often gets the worst of it in the uproar that is certain to salute one.

The great four-masted American sailing ship "Shenandoah," while coming home from Liverpool once, had a lively experience with waterspouts. When she got within five hundred miles of Sandy Hook, the wind suddenly changed, a great bank of clouds just ahead parted, and there, coming down, driven before the gale, appeared six great waterspouts at one time.

One rushed by, just clearing the bowsprit and head-sails by a few yards. Another came at her amidships, threatening to carry the mainmast

away, and the captain just avoided by quickly turning the ship toward and around it. There were two more near ones, and as they were too close to run away from, the big ship was "luffed" up and steered right between them. The ship was saved, but what her fate would have been had she been struck by one can only be imagined from the captain's description of the waterspout that passed astern. He said it seemed to be fully twenty feet in diameter, and of solid water reaching to the clouds.

On another occasion the steamer "Piqua" had a still more uncomfortable experience with these wandering giants of the ocean, near the Bermuda Islands. There she met a cyclone upon whose outer edge there hung a great number of spouts—all dancing and pirouetting here and there, twisting and turning and balancing to partners as if engaged in an elephantine quadrille.

The captain became bewildered, for whichever way he turned his steamer, he was headed off by the surrounding waterspouts. At last, just as he imagined he had steamed safely away, two of them made a rush, headed him off, and struck the starboard side of the steamer's iron bow a tremendous blow. Then there was a commotion indeed. The broken columns of water dropped in tons on the forward deck, smashing the pilot-house and bridge-ladder, tearing down thirteen ventilators, and dashing to the deck two sailors badly wounded. The ship staggered and rolled as the weight of water poured over her sides in a Niagara of foam and spray, and for some time she could make no headway.

While the two spouts were having their frolic with the sorely beset steamer, the others were whirling about as if dancing in glee at the commotion they had caused. From the black clouds above there shot down blinding streaks of lightning, which, although they missed the ship, so filled the air about her with electricity that it settled upon the metal tips of all the spars, glowing and sparkling there steadily with the beautiful light known as "St. Elmo's fire."

SOME CURIOUS MARINERS

BY C. F. HOLDER

One bright spring morning, two boys were walking out into the open country, near the little village of Cowes, on the Isle of Wight. Each lad carried under his arm a miniature cutter. It was the day of the great race between the "Sea Mew" and the "Prince Albert," the reputations of which, as winning cruisers, had been earned in many a hard-fought battle on the pond then in sight. A number of boys were already at the shore, and their boats, beating up and down the lake, gave it a very animated appearance. As Ralph and Dick approached, bringing the champion cutters, all the competitors moved to the head of the lake, and soon the signal for the race was given. The "Sea Mew" and the "Prince Albert" got off first; then came the smaller boats; while following up the race, some in a skiff and some along shore, the boys shouted and cheered the imaginary skippers of the various craft, who, it must be confessed, sailed them in a rather curious way. As the "Prince Albert" rounded the stake on the home-stretch, a queer personage came aboard. The boys were allowed to put their craft about, and Ralph had waded out and was just about to stop his boat, when it came in collision with a floating mass of leaves that threw it up into the wind. From the wrecked leaves nimbly darted the only survivor, a large spider, so alarmed at the catastrophe that it reached the crosstrees of the "Prince Albert" before it even looked about it.

"The 'Prince' has been boarded by a ship-

THE SPIDER AND HIS CRAFT.

wrecked crew!" shouted Ralph, giving the mast a rap that sent the spider to the topmast-head.

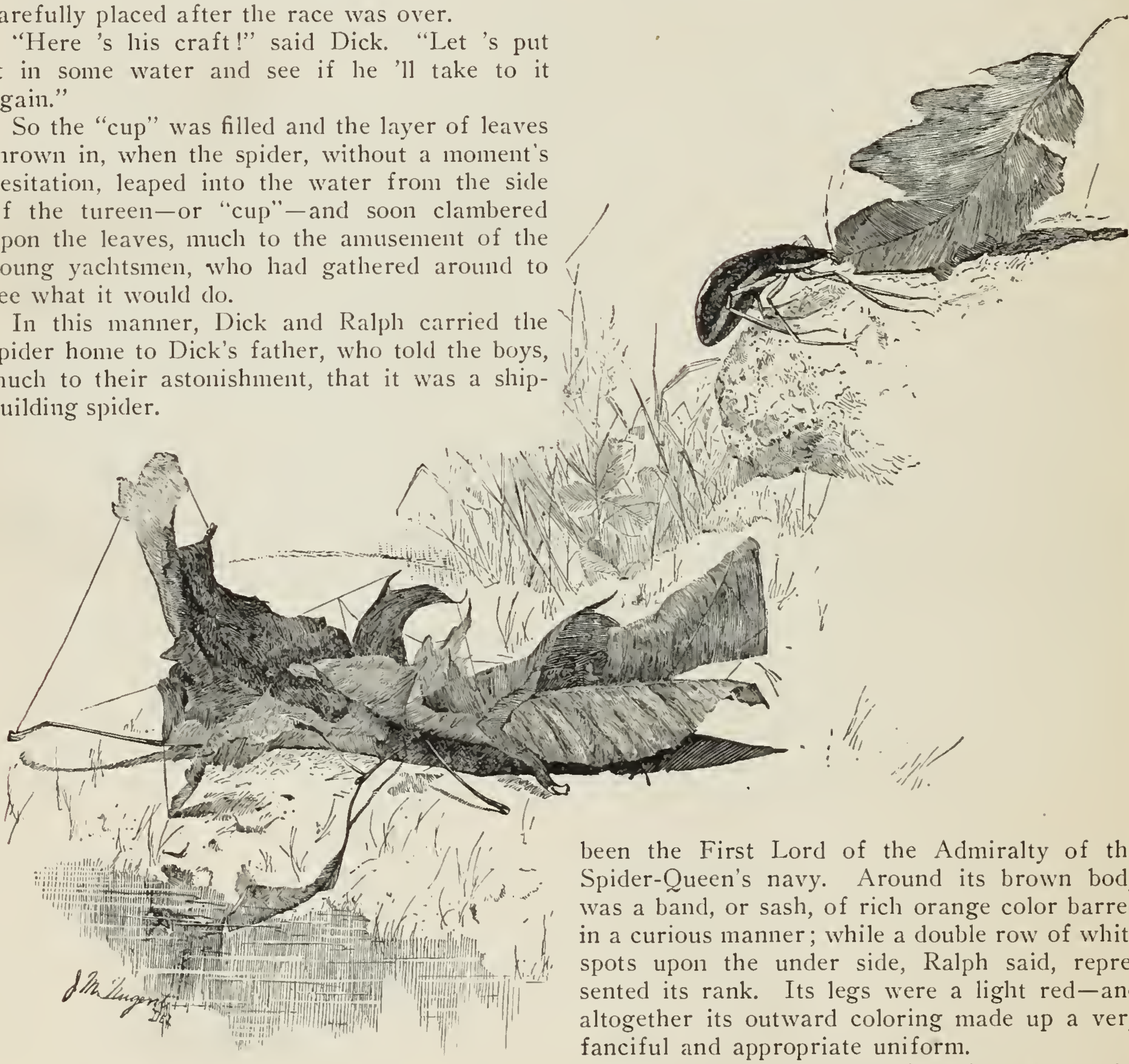
"Let him stay," said Dick, picking up the leaves that now floated by. "You ran him down, and now you must take him ashore, or we 'll treat you as they did the man in America who was tarred and feathered and carried in a cart."

So the spider was taken back by the cutter to the starting-point, and it must have brought good luck to the cutter, for the "Prince Albert" came in ahead and won the "cup," as the boys called the old-fashioned blue soup-tureen, ornamented with figures of Neptune and dolphins. And within this receptacle the shipwrecked spider was carefully placed after the race was over.

"Here 's his craft!" said Dick. "Let 's put it in some water and see if he 'll take to it again."

So the "cup" was filled and the layer of leaves thrown in, when the spider, without a moment's hesitation, leaped into the water from the side of the tureen—or "cup"—and soon clambered upon the leaves, much to the amusement of the young yachtsmen, who had gathered around to see what it would do.

In this manner, Dick and Ralph carried the spider home to Dick's father, who told the boys, much to their astonishment, that it was a ship-building spider.



THE SPIDER BUILDING HIS BOAT.

"Examine the leaves more closely," he said. "Don't you find that the bunch has not been accidentally caught together, but that the leaves have been drawn carefully one over another, and fastened together by silken cords, forming a perfect boat?"

The boys soon saw that this was indeed the fact, and, much interested, they started out next day, determined to become better acquainted with these nimble little boatmen. They were amply repaid for their trouble, for they had not gone far when Dick cried:

"Here is one, Ralph!" In a little bay, Dick had discovered a small bunch of leaves whirling round and round, and lying closely upon it a large and handsome spider that might easily have been the First Lord of the Admiralty of the Spider-Queen's navy. Around its brown body was a band, or sash, of rich orange color barred in a curious manner; while a double row of white spots upon the under side, Ralph said, represented its rank. Its legs were a light red—and altogether its outward coloring made up a very fanciful and appropriate uniform.

But I grieve to say that the spider was really a pirate of the boldest and most cruel type. Finding that the circular motion was caused by the peculiar way in which the turned-up tip of a leaf caught the breeze, Ralph gave the craft a start,

and away it went before the wind, the red-legged skipper lying low for plunder.

Near the head of the pond several members of the *Dolomedes fimbriatus* family (for this is their scientific name) were found, and the boys came upon one fellow in the very act of starting out on a voyage.

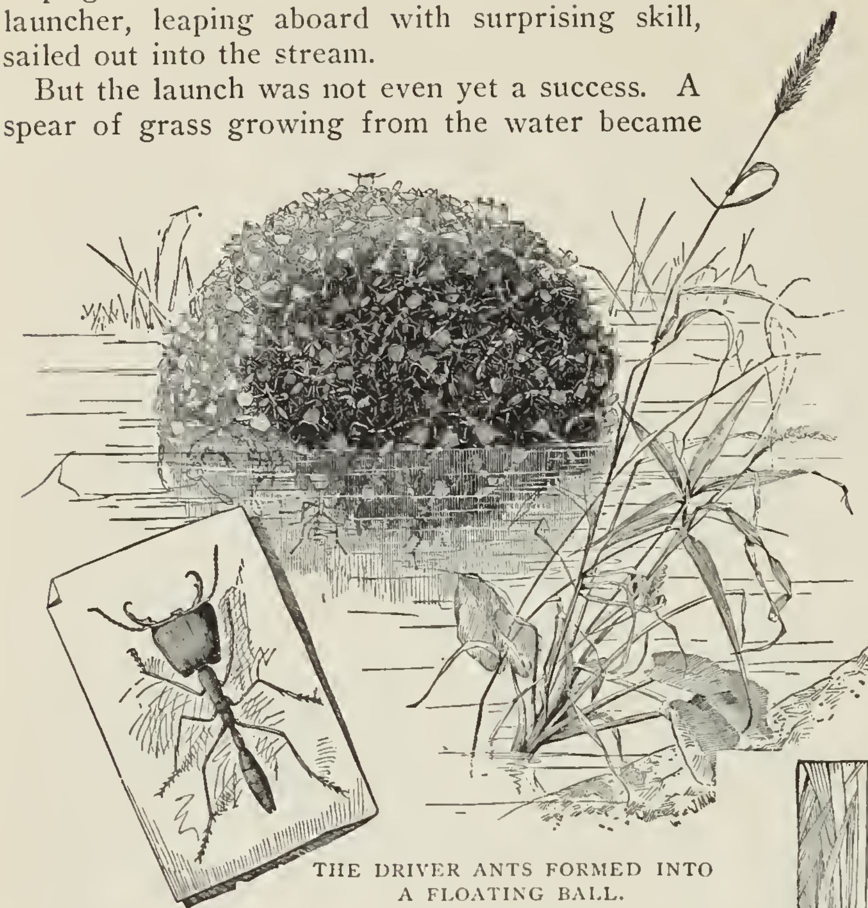
By lying upon the bank and keeping very still, the lads finally gained possession of many secrets of this cunning ship-builder. At first the spider seemed to be looking for something in the grass near the water's edge; finally, he seized upon a dead leaf, which he dragged down a slight decline, where the boys now saw several other leaves collected. By deft movements of his long legs, the leaf was lifted and tucked in between the others—the builder lashing them together by silken cords which he spun, and fastening them by a simple pressure of his body against the leaf. This leaf being satisfactorily placed, another was brought, and the same process repeated, the creature running rapidly about, passing silken cords over the entire mass, and now and then raising himself up and down, as if testing the strength of his craft. The vessel gradually grew in size until it was an inch and a half thick and four inches across, when it seemed to satisfy its owner.

THE SPIDER THAT LIVES UNDER WATER.

The spider now ran down to the water several times, returning every time thoroughly to inspect the vessel; finally, taking the craft in his strong mandibles, or jaws, he drew it several inches toward the water. Then, resting for a moment, he took it a second time by the side and drew it fairly to the water's edge. Once there, he took a last hold, the leafy

ship glided clear of the shore, and the gay launcher, leaping aboard with surprising skill, sailed out into the stream.

But the launch was not even yet a success. A spear of grass growing from the water became entangled in the silken cables, and stopped the fairy craft. The spider rushed at the obstruction, seized it in his mandibles, and, to the astonishment of the watchers, walked down it into the water. Soon he reappeared and again scrambled aboard. But as he now seemed to be greatly agitated and disturbed, the boys here interfered, and cast off the raft for him, whereupon the skipper settled down as if completely satisfied. If they touched him with a blade of grass, he darted into the water and clung to the under side, coming out when the danger was over. Soon an unfortunate fly alighted near the raft, when the pirate, instead of rowing his boat alongside, actually dashed into the water to secure his victim, swimming back to the raft to devour it at his leisure. The last the boys saw of the spider, he had jumped again at something that rippled the water; but he never returned. Possibly a self-satisfied young frog that soon hopped upon the bank could have explained the absence of the skipper of the now deserted craft.



THE DRIVER ANTS FORMED INTO A FLOATING BALL.

Thoroughly interested, the boys repeatedly watched the spiders, and studied their manners and their labors. They found also another spider, which, although it did not make a raft, had no fear of the water, and frequently went fishing; while Dick's father told them of still another that lived under water by carrying down bubbles of air with it. Its home, too, might be called a queer diving-bell, as may be seen from the illustration.

There are certain ants that show quite as much intelligence as the spider, and the "driver ants" not only build boats, but launch them, too; only, these boats are formed of their own bodies. They are called "drivers" because of their ferocity. Nothing

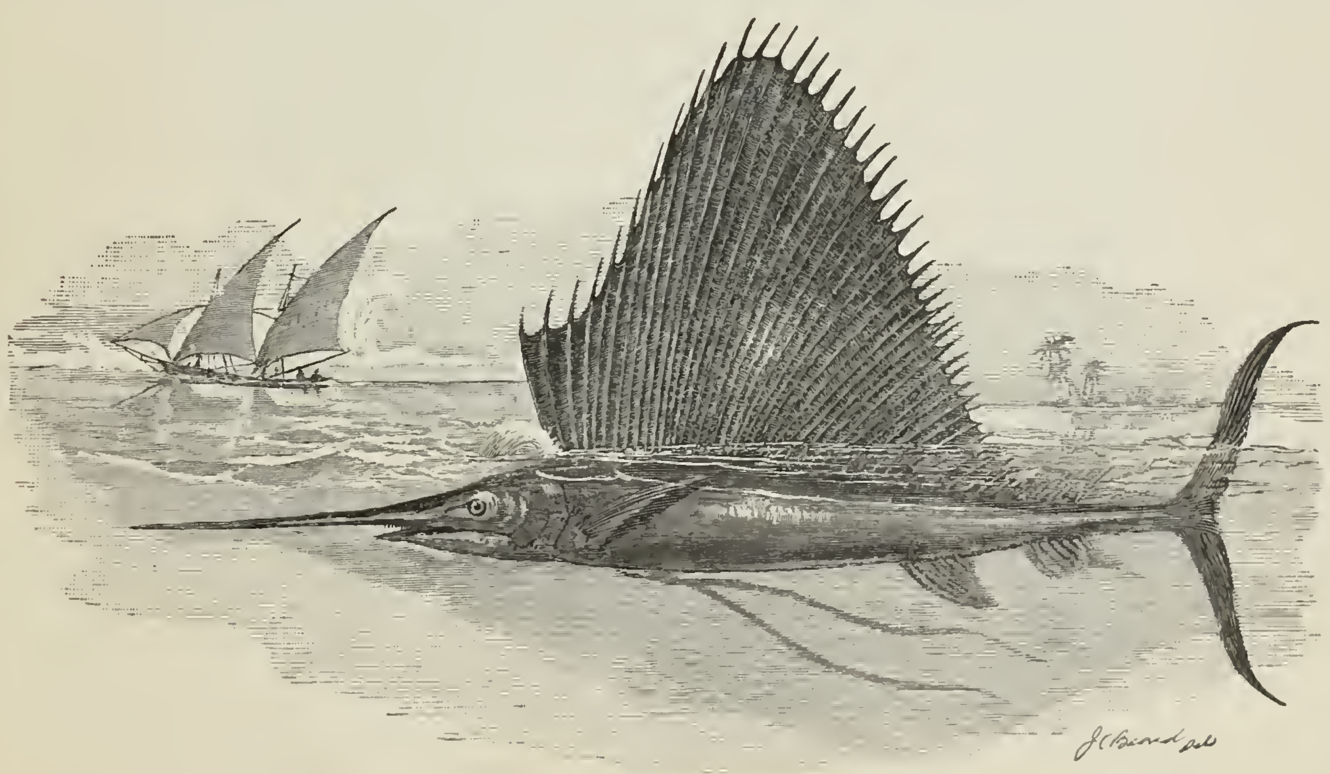
THE GREBE AND HER FLOATING NEST.

can stand before the attacks of these little creatures. Large pythons have been killed by them in a single night, while chickens, lizards, and other animals in Western Africa flee from them in terror. To protect themselves from the heat they erect arches under which numerous armies of them. pass in safety. Sometimes the arch is made of grass and earth gummed together by some secretion, and again it is formed by the bodies of the larger ants, which hold themselves together by their strong nippers, while the workers pass under them.

At certain times of the year, freshets overflow the country inhabited by the "drivers," and it is then that these ants go to sea. The rain comes suddenly, and the walls of their houses are broken in by the flood, but instead of coming to the surface in scattered hundreds and being swept off to destruction, out of the ruins rises a black ball that rides safely on the water and drifts away. At the first warning of danger, the little creatures rush together, and form a solid ball of ants, the weaker in the center; often this ball is larger than a common base-ball, and in this way they float about until they lodge against some tree, upon the branches of which they are soon safe and sound.

One would scarcely look for ship-builders among birds, so many of which are boats in themselves, going either upon or under the water; but in the curious family of grebes, one branch of which produces the beautiful feathers so coveted by ladies, there is one kind that forms a nest which is a veritable ark. Instinctively these birds seek the low boggy marshes to build their nests. But there they are in continual danger from the high tides that often cover the marshes, or from the drift-wood which washes in, or from many other accidents. So the ingenious grebe, looking like a clerk with feathery pens behind her ear, constructs a nest that will rise and fall with the tides, and can be moved from place to place. The boat is first built of rushes and grass; this is then packed with moss, and lined and relined until it is perfectly water-tight; and in this the eggs are laid. The home either is anchored to tufts of grass, or drifts, perhaps, here and there, though always guided by the mother-skipper, as she stands by the helm in all kinds of weather. We have seen that the spider is completely at the mercy of the wind, but the grebe propels her boat along. If the young are half grown, they readily take to the water; but if they are just hatched, the mother, at the approach of danger, steps upon one side of the boat, and uses one of her webbed feet as an oar to paddle away from the enemy into one of the innumerable inlets or lanes in the marsh, where she is almost sure to escape.

In the warm waters of the Indian Ocean a strange mariner is found that has given rise to many curious tales among the natives of the coast thereabout. They tell of a wonderful sail often seen in the calm seasons preceding the terrible hurricanes that course over those waters. Not a breath then disturbs the water, the sea rises and falls like a vast sheet of glass; suddenly the sail

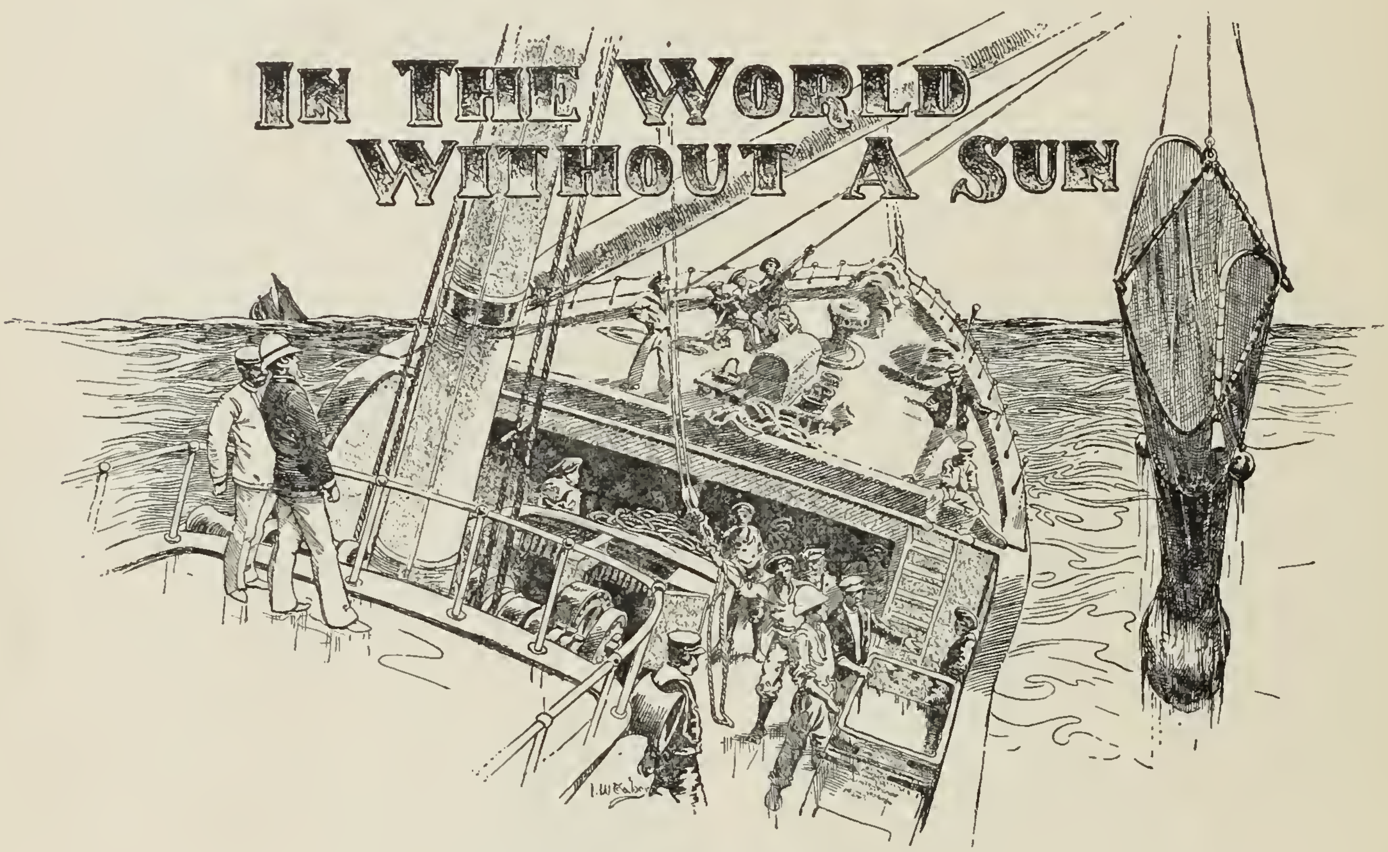


THE SAILOR-FISH OF THE INDIAN OCEAN.

appears, glistening with rich purple and golden hues, and seemingly driven along by a mighty wind. On it comes, quivering and sparkling, as if bedecked with gems, but only to disappear as if by magic. Many travelers had heard with unbelief this strange tale; but one day the phantom craft actually appeared to the crew of an Indian steamer, and as it passed by under the stern of the vessel, the queer "sail" was seen to belong to a gigantic sword-fish, now known as the sailor-fish. The sail was really an enormously developed dorsal fin that was over ten feet high, and was richly colored with blue and iridescent tints; and as the fish swam along on or near the surface of the water, this great fin naturally waved to and fro, so that, from a distance, it could easily be mistaken for a curious sail.

Some of these fishes attain a length of over twenty feet, and have large, crescent-shaped tails and long, sword-like snouts, capable of doing great damage.

In the Mediterranean Sea, a sword-fish is found that also has a high fin, but it does not equal the great sword-fish of the Indian Ocean.



BY H. S. CANFIELD

AMONG the passengers on board the United States steamship "Petrel," detailed to make deep-sea soundings under the auspices of the Smithsonian Institution, were Professor George Crenshaw of the Smithsonian Institution and Robert Lessing, his nephew. Bob was recovering from typhoid fever, and his uncle had secured him the berth of "custodian of instruments." The opportunity for combining a health-giving cruise with the chance to earn a little money on so interesting an expedition was one not to be missed by the wide-awake boy.

The mission of the boat was to take soundings in the lower portion of the Caribbean Sea. She was small, trim, and powerful, and neat as a pin from stem to stern. Her officers were a jovial and gentlemanly crew, and they took a liking to the pale, quiet boy who was never in the way, did not ask needless questions, and seemed anxious to bear a hand at whatever would be useful. The professor was in his element, telling stories, singing snatches of sea-songs, and overhauling the instruments for specks of rust. They went by islands whose "shores, like playhouse scenes, slid past their wondering eyes." They plowed waters of a blue almost dazzling. They sighted the Southern Cross, and that great constellation burned to the southward like a beacon. Then they slacked speed and began sounding.

The rope was made of thin wires; it ran from

a reel full of levers, wheels, and cogs. The reel had brakes on it to counteract the increased weight of the wire as it paid out the miles; it was screwed firmly to a stout platform built out from the side of the ship. Utmost care was taken to prevent the wire kinking, for when it kinked registered the temperature, set itself, and stayed set. There was a little box which opened itself at the bottom, filled itself with sea-water, and shut. There was a valved tube which collected mud or sand. There was a cylinder which registered the pressure of the water; sometimes it was

A GLIMPSE INTO THE WORLD WITHOUT A SUN.

it broke; otherwise, as the professor said, "it would hold a buckskin mule with black stripes around his legs." The weight to carry the wire down was attached to its end, and when bottom was reached this weight came off automatically and stayed down forever. Here and there above the weight instruments were attached. One of them was a thermometer, which did not act until it was within three feet of the bottom. Then it as high as eight thousand pounds to the square inch.

"That pressure," said the professor, "would thin a man out like a pancake."

The "Petrel" was not only a sounder, but a fisherman, and it was this work which the professor was superintending and recording. When it began he was busy from morning until night, and had no time for jokes except such as forced

their way out of him in spite of himself. He had great alcohol-jars in which the smaller specimens were preserved, and he walked around the bigger ones as they sprawled, and measured them and photographed them and examined their tissues in steady delight. He told Bob that the work was of exceptional interest, because scarcely a haul was made in which he did not see something that no man had ever seen before, despite the fact that deep-sea fishing had been going on for years, so vast is the ocean floor and so innumerable the varieties of the inhabitants.

On the deck were large steel drums with cables wound about them, and these pieces of intricate machinery let down the weighted trawls by steam and hauled them up. Once they were down, the "Petrel" either steamed at one-eighth speed or drifted on the current, and after a while the strain was put on and the drums began to turn slowly in the uplift. At first the engines groaned, because the steel nets always became half sunken in the soft bed; but as they came up, the water washed the mud from their meshes, and they reached the vessel's side clean and alive

A DEEP-SEA COMBAT.

with the most wonderful squirming or flapping things. Never a man in his wildest dreams had such visions as those which confronted the watchers on the "Petrel's" deck.

Bob got an object-lesson one day in the meaning of sea-pressure. The sounding-wire had been let down, with a hollow metal sphere attached just above the sinking-weight. This sphere was a foot in diameter and made of finely tempered steel. The wire was wound in, and not twenty feet away the fishing-trawl was also coming in. They reached the surface simultaneously as he peered over the side. The steel sphere had been mashed into a thin disk and one of its edges rolled over in a cylinder. In the trawl were half a dozen specimens of deep-sea life, and one of them, as it came into the air, blew up like a toy balloon. This fellow had been taken about half-way up, and being used to a pressure of some thousands of pounds to the square inch, had naturally expanded rapidly when that pressure was released.

"We have brought up thousands of species," said the professor one day, in a lecturing mood, "but the government cannot hope to secure a specimen of each of the varieties, for they are too many; nor can we hope ever to capture any one of the larger kinds. They are so enormous that we could not handle them if they were caught. We know enough about the world down there, however, to know that if man could visit it, all of the wonder-stories written since time began would seem tame beside the marvels unfolded. No human imagination is equal to picturing even the least grotesque of those forms; we need them actually before us to appreciate them; and each haul of the net produces things which seem only outrageous contortions of nature. There is no sun in those abysms under miles of water, not a ray of our light ever pierces to the entrances of the vast caverns; yet there is a strange and ghostly light made by the fishes themselves, and if we could see it, we would seem to be in a land haunted by gleaming specters of the horrible. Passengers in great steamers plow merrily only a mile or two above monsters that would send them into spasms of fright if they could be seen close at hand. The deepest haul of a net ever made in the world was achieved by Americans off the Tonga Islands in the South Pacific. The trawl struck bottom twenty-three thousand feet below the surface; that is considerably more than four miles down, but even at that depth animal life was found. Those strange beings lived in water whose temperature was constantly just above the freezing-point, and under a pressure of nine thousand pounds to the square inch. To sink that net and bring it back again took a whole day of steady labor."

As a rule, however, the professor was too busy to lecture. When waiting for the net to come up he was making notes, or writing reports, or bottling specimens, and once the haul was on deck he was a man possessed by a quiet frenzy. Discoveries wrung grunts of joy from him as he pottered about, and he

seized the commoner fishes and threw them back into the waves, saying in unprofessional language: "Get out! You 're as common as pig-tracks!"

Bob saw cuttlefish with six, seven, or eight arms; these last were the octopuses, but he did not eat any of them, though the black cook took some of the squids and made delicious dishes of them. The professor said that these specimens were sextopods, septopods, and octopods; but the Latin names did not make them more inviting, or lessen the glare in their cruel black eyes.

Sometimes the net brought up coal-black things that were all mouth, with teeth fringing the gap from end to end and bent backward like curved spines; sometimes there would be a great glaring single eye, with a little mouth under it, and a little tail running away from it; sometimes a huge disk, three feet in diameter and half an inch thick, would be the chief occupant of the steel meshes—a disk with no apparent means of locomotion, having no fins or tail or visible muscles. Fish that were all curves and fish that were all angles came up; round fish, square fish, fish of bones and scales, fish of flabby, defenseless flesh; fish of the most weird forms and hues. There were sharks seven feet long and sharks seven inches long; some of the fish were shaped like pigs and some like serpents; some of them had strangely human expressions of face, and some had faces more terrible than those of the gross beings in Doré's illustrations of the "Inferno." Of devil-fishes and squids alone there were hundreds of different kinds; some of these floated through the water like milky clouds, and at great depths emitted steady halos of light like electric lamps in a drizzle.

But it seemed to Bob, when he had grown rather more used to these monsters, that it was in adapting and placing the eyes that Nature had played her very strangest pranks. They caught one fish far down in the Caribbean that had no eyes at all, nor any places for eyes, but long antennæ ran out from its nose by which it felt its way and found its food. In the next haul was a fish with two convex lenses in place of eyes. These lenses were highly polished, or burnished; they were of a golden hue, and they gleamed in the sunlight like jewels. Another fish, a big fellow, had eyes which grew on stems, or stalks, that stuck out six inches from its head. Then came one with an eye that grew on a long stem like a lily-stem, quite eighteen inches from the nose, and the professor said that it was an eye made for poking itself into other fishes' business. The stem was flexible and waved backward and forward, or bent with its own weight; and sometimes the fish traveled with the eye doubled under it about the middle of its body, or trailing in the sand or mud. Some of the eyes when put into sea-water in the dark shone like lanterns; others of the fishes had brilliant spots along their sides that emitted a ghostly radiance, and they seemed to have lighted port-holes, or windows, like a slender steamer rushing through the seas after night.

Bob noticed that the skipper and officers seemed proud of the efficiency of the nets, and particularly of the sounding-apparatus, and he knew why, one day, when the skipper pointed at the reel with its wire and said:

"That is the work of one of our boys. His name was Brooke, and he was a middy at Annapolis, hailing from Virginia. It was away back in 1854 that he made a deep-sea sounding-rod, but it was so ingenious and so correct that all deep-sounding apparatus of the present day is based upon it. Other fellows improve it now and then—American fellows or foreign fellows; they put in a cog here or a ratchet there, but it is Brooke after all. He made the key that unlocked that black world down below us."

So the days went on, and Bob saw many things that he will remember as long as he lives. Strange, weird lives faded and went out under his eyes; strange bits of coral fascinated him; rocked on the ceaseless swing of the southern ocean, he dreamed at night of its wonders.

At last the voyage was over, but his head was crammed with odd facts; he mentioned the names of mysterious creatures as familiarly as he had formerly talked of golf or ball; ruddy, insistent, triumphant health came to him in plenty. He was as brown as a berry and his eyes were crystal clear when he climbed down from the van which bore the professor's treasures and rung the doorbell of his own home.

"Mother," he said, when her arms were around his neck, "it has been like a dream—I have been in another world!"

THE · BOOK · HOUSE ·

A BOOK is just a House of Thought,
Where many Things and People live.
Beyond its doors Great Things are taught,
And all its Dwellers give and give.
So walk right through the open door
With kindly Heart and brain awake.
You'll find in there a Wonder Store
Of Good Things, all for you to take.

The Dwellers in *your* Book House know
All sorts of tales to tell to you,
And each will try his best to show
The way those tales of Wonder grew.
For this our Book House Friends expect
A trifling payment in return;
Just thoughtful Kindness and Respect,—
That's all they *ask* for all we *learn*.

John-martin

This BOOK belongs to

THE BOOK TREE

A BOOK TREE is a Knowledge Tree,
As almost anyone can see.
Long, long ago its seed was sown;
For *years* and *years* the Tree has grown.
Ten thousand thousand Hearts & Heads
Have cared for it, so now it spreads
Its Roots and Branches far and wide,
And casts its shade on every side.

This Tree bears Fruit of different kinds
For many Hearts and many Minds.
So all you Children have to do
Is just to take what's *best* for you.
But no one ever soils or breaks
The Golden Fruit he *needs* and takes,
And no one ever bends or tears
The Books this Tree of Knowledge bears.

"John-martin"

H.S.

Copyright 1916 by Morgan Shepard